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EOCHEMICAL PROPERTIES AND PROCESSES F SALT ACCUMULATION IN SINKIANG SOILS

A. KOVDA and G. V. ZAKHAR'INA, V. V. Dokuchayev Soil Institute, Academy of Sciences,
SR

The broad advances in the attempt to con- r the deserts of the Chinese People's Re- lic, constitute a great event in the history , mankind. This article is a preliminary re- t on the attempts to utilize the virgin, and ıost generally saline desert lands of Sinkiang.

The earth has several large desert centers ated in South America, Australia, North ica, Arabia, and Central Asia.

Judging by the amount of atmospheric pre- itation, total evaporation, and air dryness, desert of Central Asia, particularly those southern Sinkiang, are among the most arid. re, atmospheric precipitation averages ut 30-50 mm per annum with an evaporation 2,000 mm and more. In the lowland of Tarim, cipitation is sometimes as low as 9-10 mm le in Turfan there are years without precip- ion. Because of the extreme dryness of air soils, and the high soil temperatures, even sum is often dehydrated and converted to anhydride. Such conditions have been ob- ved only in Africa and Arabia.

Sinkiang deserts are characterized by a nbination of high mountains and deep en- sed depressions located below mountain es and below sea level. This indicates a l-pronounced hydrological and hydrochemi- condition without any outflow. The products veathering and soil formation circulate with- he enclosed depression. There is an eternal v of solutions from the mountains to the de- ssions. Therefore, artesian waters are nd almost everywhere in Sinkiang. Here process of salt circulation proceeded for ny million years. The simultaneous pre- itation of salts dates from at least the Terti- Period. The peculiar formations, both ient and contemporary, may be traced to continuous process of salt accumulation.

Geological and geographical investigations ıorthwestern China emphasized the vigorous tonic activity in that country. The continuous process of folding contributes to the build-up of pressure and the forcing of solutions towards the surface, leading to even greater salt accumulation.

The lack of life and bareness of these regions, which are literally devoid of fauna and flora, is astonishing. Quarternary and more ancient sediments are relatively poor in clays, while the soils are extremely poor in humus. Therefore, it is quite possible that such elements as potassium and magnesium are not fixed in soil materials, but migrate to the centers of drainage and salt accumulation.

These are the main peculiar aspects of the natural conditions affecting the geochemical salts in Sinkiang.

The occurrence of sodium carbonate accumulation in Sinkiang, a fact new to science, may lead to the assumption that sodium salinization is more widespread than previously thought. Only a few years ago nothing was known about sodium carbonate accumulation in Sinkiang; it was discovered when virgin saline lands were cultivated. Sodium carbonates may form in waters and soils with low ground-water concentrations (0.5-5.0 g/l).

The sodium carbonate accumulation is most evident where plutonic waters with low salt content come close to the surface (Manas River basin, seventh division). The soils of the first meadow terraces of the Aksu and Tarim Rivers also show sodium salinization. To utilize these soils, we must add gypsum. There is a characteristic association of centers of sodium carbonate accumulation (sodium in soil materials and water) with such salts as NaCl and Na_2SO_4. The causes for the chlorid-sulfate salinization are the removal and accumulation of salts from the tertiary parent materials, and also the outcropping of deep oil-bearing rocks.

The question arises whether or not the very large amounts of sodium will cause the solonetzation of soils upon the desalinization of sodium chloride solonchaks. But these fears are unfounded, since these soils are generally high in gypsum. Only occasionally in northern Sinkiang, with a deep water table (8-10 m), do we find takyr-like solonetzic soils, where a crust forms, where there is muddiness in the wet state, and a high degree of compactness in the dry state. Here, there is gypsum, but it is located below the plow layer (at a depth of 30-40 cm). Such soils are comparatively rare. They may be "self-improved" by plantation treatment. Nevertheless, it is always desirable to find out if there is gypsum in the soils and at what depths.

Geochemical Features of Sinkiang

The exceptional dryness and lack of life cause the accumulation of nitrates in the solonchaks of southern Sinkiang. We first found this condition in Turfan.

As we know, the toxicity of nitrates is extremely high. Nitrates in quantities of tenths of a percent are lethal to plants. Therefore, if nitrates are not determined in analyses, the toxicity of salts in saline soils of Sinkiang will not have been fully evaluated. Moreover, nitrates may be used in the chemical industry, in the manufacture of explosives, and in other branches of the national economy. In the salt accumulations of Sinkiang, compounds of potassium, magnesium, and other salts are found along with the nitrates. Here we also find accumulations of compounds of rare elements, such as rubidium, cesium, bromine, and iodine. In Chile iodine is associated with saltpeter, and bromine is most often found where brines of petroleum origin reach the surface. In general the salt deposits of Sinkiang are of interest to reclamation specialists and agronomists, and to chemists and salt scientists. We think that these accumulations can be utilized by the chemical industry of Sinkiang.

A second geochemical peculiarity of Sinkiang, as compared with other deserts, is the almost general formation of a salt crust. The widely distributed pressure greatly stimulates the ascending flow of ground water. Constant pressures of 30-40 atm and sometimes 100 atm displaces all salt accumulations upward. Because of extremely high evaporation and an insignificant amount of precipitation, there is no downward flow of ground water. In this the Sinkiang deserts differ from the deserts of Africa and the USSR, where there is always a descending flow of solutions in winter.

The salts in the soil profile are usually found to a depth of 1.5-2.5 m, but they are concentrated (70%-80% of the total amount) mainly in the upper soil horizons, and there they form a peculiar salt shell up to 20-40 cm thick over the soil profile. Such crusty solonchaks are not found even in the deserts of Arabia and Africa. As mentioned previously under these conditions, Calcium sulfate is mainly anhydrous; dews and brief showers cause its cementation. The state of sodium chloride is also unusual, for it acquires an extraordinary compactness and monolithic structure.

In our opinion it is unwise to displace 70%-80% of the supply of salts (up to 2,000 metric tons per ha in the root zone) to a certain extent into the ground water by leaching these crusty solonchaks, nor is it advisable to drive these solutions into the rivers which receive the ground water. It is more appropriate to use the salt crusts as raw materials for the local chemical industry than to leach them into the soil. Therefore it is necessary to investigate thoroughly the chemical composition of these crusts. It is quite possible that small salt factories, utilizing solar energy might be organized on the state farms. At the same time drainage waters of high salt concentration could also be used as raw materials. Gypsum obtained by evaporation could be used as alabaster in the construction industry, and as a fertilizer on sodium-salinized lands.

Another geochemical characteristic of Sinkiang is the very wide occurrence of the residual type of salt-accumulation. This is found here even in the gravel of alluvial fans, a situation which thus far we have not found anywhere else. Only in the deserts of Egypt do we find similar relict solonchaks. From the reclamation viewpoint, these solonchaks are easy to utilize, since they are usually elevated and have some natural drainage. They can be leached without washing the salt into the soil materials. A second rare type of salt accumulation — diluvial — proluvial accumulation — also occurs widely in Sinkiang. Externally it is difficult to distinguish diluvial-proluvial from residual salt accumulation. But the former process is contemporary, while in the latter case it is already completed. Lands salinized by diluvial-proluvial waters may also be reclaimed without drainage simply by protecting them from the salty surface runoff.

To decide correctly the type of salinization, and the utilization of saline lands, it is extremely important to study the saline soil and ground water together. This avoids mistakes such as irrigating without drainage on solonchaks where the water table was 10 m or more deep. This was erroneously put into effect in many places on solonchaks and other saline lands where the water table is close to the surface. Salt accumulation is especially active where the water table is 1.5-2.0 m deep. But even when the water table is 3-4 m

, solonchaks are still alive and active, as observed by the soil scientists of the ang expedition. The capillary rise of ions may reach a total height of 5-6 m, sometimes more. It was a great mistake nsider such solonchaks as residual and rigate them without drainage. In many es these practices resulted in increased accumulation.

he mineralization of the ground water be- irrigation in Sinkiang ordinarily amounted ss than 30 g/l which is considerably less that in Egypt or Azerbaydzhan.

hen irrigation without drainage was in- ted in Sinkiang, the deep water table rose 2 m, and what was particularly danger- the salt concentration of the water rose to 00 g/l or more (Goskhoz "Pobeda" [vic- No. 1). Meanwhile the rate of the ap- ch of the water table to the surface con- d to increase, and the critical salt level e water rose rapidly. If before irriga- there were solonchaks with a film capil- water supply in many places, then after ation they were transformed into capillary- olonchaks. The process of salt accumu- n becomes even more intense because of nadequate amount of irrigation water, his makes it impossible to regulate the regime during irrigation.

cultivating the saline soils a number of ical errors were committed, but these not of primary importance.

Principles of the Reclamation of Saline Lands

ne basic consideration in the reclama- of saline lands is the control of runoff and irculation of soil and ground water, which complished by building a network of deep s in particular features of the landscape. cannot be left to individual farms to do. rrigated and non-irrigated areas should nsidered as a whole. Often the irriga- of one tract affects another tract after a in period of time. Therefore, it is ad- le to build large drainage systems for areas. At present it is not uncommon to no main drains in goskhozes, or that they o neglected that they do not discharge the age water. This situation should be cor- d immediately. It is very desirable to and labor as well as excavators to speed up construction of the main drains, and to build pumps where the slopes are too gentle.

It is very important to control artesian water, and to prevent this phenomenon we must study the chemistry of the ground water more thoroughly. When the water is soft, wide use must be made of vertical drainage, as V. N. Kunin recommends. This relieves the pressure and also supplies additional water for irrigation; vertical drainage has proved to be sound technically and economically, but it cannot be used where the soil materials are fine-textured. It would be very desirable to build a series of large experimental wells. Undoubtedly horizontal drainage should also be used and is very important. Agricultural engineering methods and correct distribution of drains and irrigation ditches should not be overlooked; these should be alternated. This would be especially effective here where artesian water is available. Additional pressure can be obtained with large leaching rates.

Among reclamation measures we should mention the growing of rice. Contrary to reclamation practice in the Soviet Union, in addition to massive irrigation, it is often necessary to flood during the growing season (also with more extensive amounts of water), sometimes resorting even to inundation, i. e. to maintain with all available means the downward flow of water, especially during the initial period of land use. Very good agents for eliminating the rising solutions are the forest belts. With the same thing in mind continuous efforts should be made to clear out the drainage network to maintain the largest gradients.

Drains must be built on the maximum slopes, and pumps provided where the slopes are too gentle. Therefore, the discharge of waters into the drainage system should be prohibited, although this is a widespread practice. We must recommend, especially during low-water periods, the use of the water from the drainage system at salt concentrations up to 10 g/l to flush saline soils. For this the irrigated farms should be furnished with small machines to pump the water, as is done on many farms of Eastern Sinkiang.

Received March 23, 1959

METHODS USED TO ATTAIN HIGH YIELDS IN THE CHINESE PEOPLE'S REPUBLIC

M. M. KONONOVA, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

The liberated people of China are now going through a significant period of general improvement in industry, agriculture, popular education, science, art, and in other areas of national life.

As a result of the generalization of the experience of the First Five-Year Plan, the general party line is coming to life: "Taxing all our strength, striving forward, to build socialism fundamentally bigger, faster, better, and more economically . . . " (address of Comrade Chou En-lai to the All-China Assembly of People's Representatives, April 18, 1959. Cf. Pravda for April 19, 1959).

In 1958 (the first year of the Second Five-Year Plan) the Chinese People's Republic made historic progress in the development of its national economy. In only one year overall industrial and agricultural production substantially exceeded that of 1957. The Chinese people set themselves the task of continuing their advance by leaps and bounds and to strive in succeeding years for even greater successes.

A considerable role in the general improvement was played by the people's communes, first organized in 1958. In this new social organization industry, agriculture, trade, education, and military affairs are coordinated. At the same time the people's communes are the primary unit of the power of the socialist state.

The progress in agriculture has been reflected in the many published statistics. For example, in 1958, the total grain harvest was 250 million metric tons, an increase of 35% over the 1957 harvest. Thus, while in 1957 about 285 kg of grain were produced per person, in 1958 this number grew appreciably.

The increases in the total yield of food and industrial crops are due only in small part to the opening of new lands; the chief reason was an important increase in the yield of basic crop cultivation. Data repeatedly published testify to the fact that, from vast areas of our land, comprising millions of hectares, the average yield of winter wheat obtained in 1958 was 15-20 cntr/ha; that of early rice, 40-50 cntr/h and that of cotton (clean fiber) amounted to 7 cntr/ha. From small areas the yield of rice wheat, and other crops substantially exceeded the values given.

In late 1958 we were able to visit these people's communes in Kiangsi province: "Vantin," "Mir" (Peace) near Suchow, and "Oktyabr'" (October) near Nankin. These communes are located on alluvial soils of the Yangtze River valley, which is a rice-growing area. The visit to the communes coincided with final ripening and harvest of the rice. Among the lands devoted to this crop were areas of record yields (Figs. 1 and 2).

Let us cite data for one such area in "Vantin" commune: on an area of about 1 mu (the mu equals 1/15 ha) we helped to determine the biological yield of rice, which when converted to 1 ha amounted to approximately 70 metric tons. This amount was obtained from the following calculations. After transplanting, ther were 150,000 clumps of rice in 1 mu; in each clump there were 8 plants; and each plant had one spike bearing about 120 grains. Consequently, the quantity of rice grains from an area of 1 mu was $120 \times 8 \times 150 \times 10^3 = 144$ million. Since 1 kg of rice contains about 30 thousand grains, the yield from 1 mu amounted to $(144 \times 10^6) \div (3 \times 10^4) = 48 \times 10^2 = 4800$ kg o 4.8 metric tons. Thus, converting to an area of 1 ha, the yield was equal to $4.8 \times 15 = 72$ metric tons.

These calculations were made for biological yield; with the careful gathering and handling of the harvest by the Chinese farmers we may reasonably assume that the warehouse yield will not differ significantly from the biological yield.

The large harvests in the People's Republi of China are the result of continuous hard wor by the farmers, who skillfully use methods

Fig. 1. - Field of record rice yield in the "Vantin" people's commune.

. 2. - New type of high-yield early rice veloped at the agricultural experiment tation near "Vantin" people's commune.

loped through centuries of agricultural rience. In various provinces, districts and individual communes these methods differ somewhat.[1] But we may say that the individual methods are closely and continuously related in a single complex of practices, of which the most notable are: 1) deep tillage of the soil; 2) the addition of large quantities of fertilizers; primarily of local origin (organic and earth types); 3) irrigation, and in this connection; 4) thick planting, and other measures included in the so-called "8-point agricultural constitution."

Deep plowing improves aeration, permits the plant roots to spread through a large amount of soil and thus facilitates the fullest utilization of the nutrients contained therein.

Previously in the People's Republic of China only the upper layer of soil was plowed to a depth of 10 cm. Experience showed that deep tilling is an important factor in the production of high yields. The shallowest plowing depth in China is now 30 cm, while in many cases, particularly in the areas producing record yields, the plowed depth is as much as 60 cm or more with the surface layer of soil remaining on top.

Deep tilling is accompanied by the use of large quantities of local fertilizers ordinarily applied in layers with thorough cultivation of the soil. In addition, compost, excrement, and mineral fertilizers are added in the growing season as supplementary nutrients in conjunction with flooding.

---

[1] cf. Asarov, Kh. 1959. How our Chinese friends get record yields. Sel'skoye khozyaystvo. No. 15:8263; Naydin, P. 1959. "In the land of great feats of labor. Sel'skoye khozyaystvo. 60:8314, and 61:8315.

Local fertilizers applied at rates of approximately a hundred metric tons per hectare (cf. data below) provide a source not only of mineral plant nutrients but also of carbon dioxide used in photosynthesis as well as of vitamins, antibiotics, growth-promoters and other substances having specific effects on plants.

The favorable soil conditions provided by the labor of the farmers, the abundant solar radiation, irrigation, and the long period of high temperatures over a large portion of China – all assure better plant growth even with thickly planted crops, which form an important part of the improvement program.

Of great interest in this connection is the growing of rice in China. Rice is first grown in nursery fields, then it is transplanted in clumps to previously tilled and fertilized growing fields, where it grows to maturity and harvest. In the example cited, where record yields were obtained in the "Vantin" people's commune, the density of the rice after transplanting was 18 million plants per ha, with a feeding area for each clump (containing eight plants) of about 45 cm^2.

In some cases, however, in areas of extra-high harvests, the rice is transplanted a second time in the same tract at the approach of flowering but with very close spacing of the plants. The areas released by transplanting the rice are planted with other crops (for example, vegetables, legumes, grains, etc.).

Obtaining large yields in the People's Republic of China involves the solution of a number o problems, among which the problem of maintaining soil fertility at a high level and supplying the plants with mineral nutrients are of preëminent importance. As we know, most agricultural crops (excluding legumes) deplete the soil of nutrients if fertilizer is not added, sinc the removal of these nutrients in the harvest is not compensated completely by the return of th roots and residues (Table 1).

The return of nutrients to the soil, and of nitrogen in particular, is also accomplished by the crops planted through root secretions by rootlets and root hairs which die as the plant grows. Very important in maintaining the reserves of soil nitrogen are the free-living nitrogen-fixing bacteria. Some nitrogen reaches the soil with atmospheric precipitation The size of these added quantities for the soil conditions of China is still not known. And, judging by experience in the middle latitudes of Europe, we may assume that by all means considered, including roots and residues, about two-thirds of the nitrogen removed by the top parts of grain crops are returned.

The problem of compensating the removal of soil nutrients assumes an even more critical aspect with high yields. Thus, a rice yield of 50 cntr/ha (a harvest of this size was obtained in China on millions of hectares of land in 1958) removes approximately 125-140 kg of nitrogen and 55 kg P_2O_5 from one hectare in the grain and straw. If we assume that

Table 1[a]

Quantity of nitrogen and phosphorus removed by plants and returned to the soil with roots and residues

Crop	Yield cntr/ha	Total removed in upper parts of plant, kg/ha		Amount in roots and residues, cntr/ha	Amt. contained in roots and residues, cntr/ha	
		N	P_2O_5		N	P_2O_5
Wheat	20–25 (Grain)	60–85	25–30	20–25	20–23	10–15
Rice	50 (Grain)	125–140	50–55	Not det'd.	20–25	5–7
Cotton	20–25 (Raw cotton)	60–120	20–50	20–25	15–20	5–10

[a] Compiled from data by the following: 1) I. V. Tyurin. 1957. Pochvovedeniye, No. 8; 2) M. G. Chizhevskiy and L. P. Charuyskaya. 1958. Pochvovedeniye, No. 7; 3) M. A. Belousov and I. I. Madraimov. 1955. Trudy Ak-Kavakskoy Tsentral'noy Agrotekhnicheskoy Stantsii, Tashkent; 4) Neunylov, B. A. 1956. Dissertation for the degree of Doctor of Agricultural Sciences (defended at the V. V. Dokuchayev Soil Institute, Akademy of Sciences, USSR).

enishment by all the means discussed pre-
sly returns two-thirds of the total amount
trogen and phosphorus removed by the
s, then the annual deficit amounts to about
 of nitrogen and 15 kg of P_2O_5. To pre-
reduction in soil fertility it is necessary
ake up the loss by adding mineral and or-
 fertilizers and also by sowing leguminous
s. As a matter of fact, the nitrogen con-
of the alluvial soils of the Yangtze River
y contain about 0.15% nitrogen in the layer
0–20 cm or about 4500 kg/ha. With this
al nitrogen deficit amounting to some tens
lograms, this reserve may be depleted in
atively short time.

ut historically it has been characteristic
riculture in China to replenish the biologi-
ycle as fully as possible with mineral and
nic substances by making maximum use of
arious kinds of local fertilizers. The
ing farmer who uses refuse, river mud,
eed, furnace clay, shale, and industrial
ousehold wastes to fertilize his land, is
mbodiment of centuries of experience by
eople; the practice results from historical-
ical and economic conditions. The Chinese
ant with a small tract of land was forced to
his planting to crops yielding mainly food
ucts (principally grains) and to hold his
s acreage to the minimum that would sup-
his livestock. The poorly developed ani-
industry resulted in inadequate supplies of
re. The chemical industry, which remained
l in past years, could not supply the farmers
even paltry amounts of mineral fertilizers.
r such conditions the peasant was forced
e everything that nature and his household
ied to maintain the fertility of his fields.

e enormous importance of local organic
arth fertilizers was known to the Chinese
ant long ago and therefore he carefully
cted every scrap of rubbish, every leaf
ell from the tree, and returned to the soil
arbon and nutrients removed by the plants,
ctively striving to maintain their balance
ut deficit. This problem remains critical
The growing chemical industry of China
t yet able to supply agriculture with ade-
amounts of fertilizer to maintain the
ent balance in the soil. We cannot expect
den increase in the planting of leguminous
ge, especially perennial kinds; this is
planned for the future. Livestock is still
evel inadequate to supply manure. There-
at present, the application of local (or-
and earth) fertilizers retains its full im-
nce as the principal means of obtaining
ields.

the people's commune called "Mir" we
ed analyses of some local fertilizers:

	% nitrogen
Uncomposted rubbish	0.355
Composted rubbish	0.360–0.414
Compost of grass and mud	0.850
Seaweeds	0.27–3.85
River mud	0.53–1.34
Sod	0.148
Clay from furnace	0.154

Since the upper layer of the alluvial soil contains 0.14%–0.15% nitrogen, the majority of fertilizers undoubtedly enrich the soil in this important element of plant nutrition. The following figures illustrate the extent to which the nitrogen reserves are replenished by the addition of local fertilizers:

In the people's communes we visited in 1958, the areas giving record yields received up to 300 cntr of earth composts per mu or 450 metric tons/ha, which on dry weight basis amounts to about 150 metric tons/ha. If the average nitrogen content of these fertilizers is taken as 0.2%, then a standard hectare application adds about 300 kg of nitrogen. Since the production of each ton of rice grains and a corresponding amount of straw requires 22–25 kg of nitrogen, we may assume that the application of these large amounts of earth fertilizers will sustain the production of 12 metric tons of grain.

Of course, these calculations are very rough, since the nitrogen added in the earth fertilizers is in forms that only gradually transform into mineral compounds that the plants can use. But it is clear that the record yields, which require enormous quantities of nitrogen (e.g., 1.8 metric tons of nitrogen per ha are needed for a rice-grain yield of 70 metric tons/ha), may be achieved by using only fertilizers rich in nitrogen. Present agricultural practice in China achieves this by extensive application of excrement composted with soil and by planting green manures (astragalus, vetch, etc.).

The development of the chemical industry in the People's Republic of China, and particularly the increased production of chemical fertilizers will relieve the shortage of plant nutrients; in the future the program for obtaining high yields will include both local fertilizers and mineral plant foods.

The observance of this rule of simultaneous application of organic and mineral fertilizers will assure progress in obtaining high yields. The manifold functions of organic materials in soil fertility, in physiological processes, and in the biochemical nutrition of plants are attested by the findings of soil science, plant physiology, and plant biochemistry as well as practical farming. It would be a grave error to assert that progress in obtaining high yields may be achieved only by supplying the nutrient needs of plants with mineral fertilizers.

We should also remember the important fact that the use of large quantities of organic and earth fertilizers substantially changes the appearance of the soil. Thus, if we assume the weight of the plow layer (0–20 cm) of one hectare to equal 3 million kg (or 3000 metric tons), then the annual addition of 150 metric tons of dry matter per ha in fertilizer will constitute 1/20 of the weight of the plow layer. Even if we assume the complete mineralization of some part of the fertilizer, we can see that in a short time, in a few decades, the farmer can completely renew the plow layer. Since at present fertilizers are added in the People's Republic of China in conjunction with deep tilling (to 30 cm or more), naturally the time required to remake the soil profile will be longer. Nevertheless, soil scientists working in the People's Republic of China are well acquainted with soils having a plow layer which the farmer has completely renewed by the prolonged addition of local fertilizers. These soils have a high potential and actual fertility. Thus in the future the application of local fertilizers will retain its place as an important means for the thorough rejuvenation of soils.

The study of these combined techniques (deep tillage, organic and earth fertilizers, thick planting with irrigation) has absorbed the attention of workers in the people's communes as well as soil scientists, agronomists, plant physiologists, and microbiologists of the land. The generalization of the people's experience and the utilization of the modern achievements of science as regards soil and plants is the basic program of study. In particular, much attention will be given to the development of methods for the rapid and extensive manufacture of high-quality organic composts, to scientifically sound procedures for the thick plan ing of crops, and to the determination of the best depths and methods of soil tillage.

The experience gained with high yields in the People's Republic of China may also be utilized in the agriculture of the USSR. The creation of a deep plow layer without disturgin the position of the soil layers and with layer application of organic fertilizers may be utilized theoretically under various conditions of soil and climate. Greater attention must be given to more extensive production of organic composts and to the simultaneous application of mineral and organic fertilizers. Thick plan ing of some crops may be utilized in the soils of our southern and warmest regions, where there are long periods of high temperatures and intense solar radiation, with suitable agricultural techniques and artificial irrigation.

The slogan "larger, faster, better, more economically", the realization of which will bring the building of Communism closer, has significance for both our countries, joined by bonds of close friendship.

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OME PRINCIPLES CHARACTERIZING DEVELOPMENT AND ERTICAL-ZONAL DISTRIBUTION OF SOILS IN TROPICAL ND SUBTROPICAL REGIONS OF SOUTHWESTERN CHINA

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In collaboration with a group of soil scientists the Soil Institute of the Academy of Sciences China we conducted soil studies in 1957-1958 the southwestern part of the province of Yün- n, where it borders Burma, Laos, and Viet- m. The purpose of the studies was twofold: st, to study the principal subtropical and opical soils, and second, to provide guidance to the organization and methods of experi- ental work at stations on the dynamics of soil ocesses in the soils of the moist tropical ests.

The first results of the studies, obtained in 57, have been published in a paper authored Li Chang-kwei and myself.[1] The basic theses d conclusions set forth there were confirmed the studies in 1958. In addition, in the course the work new aspects and features of soil for- ation were elucidated, as affected by the verti- l changes in climate, the composition of the il-forming parent materials, and the vegeta- n, including changes caused by fires and the tting of timber. Some of the results of these idies also are given in the present paper.

The southwestern part of China in the pro- nce of Yünnan is heavily dissected mountain- s country. A large part of it is known as the nnan-Kweichow Plateau, which extends from city of Kunming to the valley of the Red ver. Its average elevation is about 2000 m, d differences in elevation run to 1000 m or ore giving it the heavily dissected character. e plateau is composed chiefly of limestones, d karstic processes are well developed, in ces assuming very unusual and fantastic apes, which have been called stone mushrooms d stone forests. The reasons behind this sort landscape are still far from fully explained. can only say that an important role was yed by ancient alluvial streams, which de- sited large quantities of gravel at great ele- tions among the rocky forms of karst.

South of the valley of the Red River rises the Ai-lao Shan range, composed of granites, gneisses and other intrusive rocks. It reaches elevations of 3500 m. The whole area between these mountains and the borders of Burma, Laos, and Vietnam is an intermontane region with a clearly developed, vertical zonal succession of natural conditions. This is also characteristic of the Yünnan-Kweichow plateau. But the similarity of the rock over vast areas (limestones) obliterates any sharp boundaries in the vertical changes in natural conditions, and this situation is greatly emphasized by the very intensive influence of man on vegetation and soil. Thus is will require considerable effort to restore the former natural landscapes and work out the principles governing their vertical zonal changes. Here the broad valley of the Red River and adjacent regions provide a gratifyingly large number of indicators, with their tropical savannah landscapes giving way to moist-dry subtropical forests at elevations of 1300-2000 m, and their more temperate forests above 2000 m. Above 2500 m the forest is replaced by grass-type of vegetation, apparently of the meadow-savannah type (Fig. 1). But we could not reach these heights, so that our estimations concerning the nature of the vegetation and soils of those areas are based on assumption.

The Ai-lao Shan range forms a natural barrier preventing the northward movement of the moist monsoon air masses from the Indian Ocean. Therefore, the tropical and subtropical landscapes, with their moist evergreen and deciduous forests, are most widely distributed to the south of this range. Here, there is no primary savannah, but there are wide areas of secondary meadow-savannah landscapes, which appeared when the forest was cut or burned over.[2]

To the north of the Ai-lao Shan, where the mountains cut off the rain, we find the most

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Some problems of the genesis and classification of tropical soils of China. Pochvovedeniye, No. 9, 3.

[2] Established by Professor U Chen-i, director of the botanical studies.

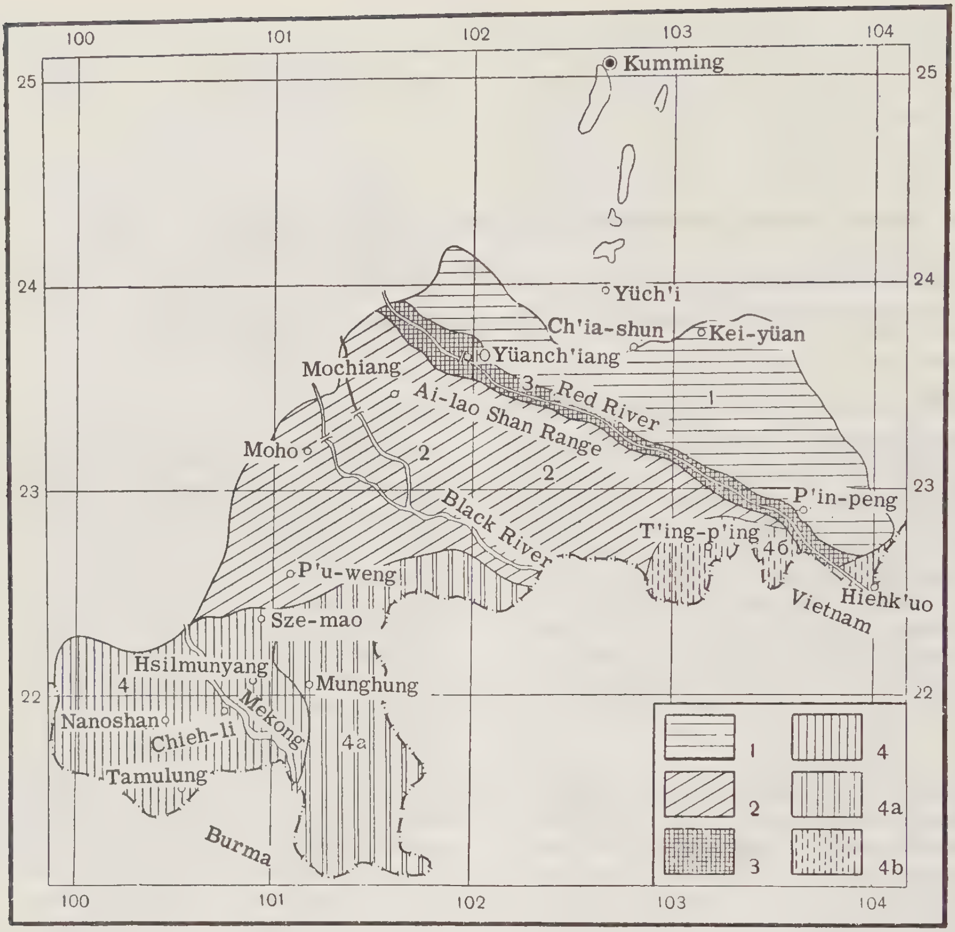

Fig. 1. - Diagrammatic map of the soil regions of the southern part of Yunnan province. Scale: 1:500,000. 1959.

Subtropical relatively dry region. 1 - red earths, brown-yellow forest soils, cinnamon-brown-red soils, and cinnamon-brown savannah soils.

Subtropical savannah region. 2 - slightly-podzolized red earths, yellow earths, secondary red earths.

Tropical savannah region. 3 - cinnamon-brown-red soils of the terra rossa group, meadow-savannah soils, secondary.

Moist-tropical region. 4 - Yellow earths, tropical and subtropical (dark) meadow-bog, red earths on lateritized (residual) weathering crust and recent red eluvium of granites and gneisses: 4a - yellow earths, secondary saturated yellow earths on limestone eluvium and meadow-yellow earths on eluvium of shales; 4b - red earths, yellow earths on ancient lateritized weathering crust (tropical and subtropical) and on recent eluvium of crystalline rocks.

pronounced aridity, as shown by the climatic data for Yüanch'iang station (Table 1), which is located in the middle and highest sector of the valley of the Red River. The lowest mean annual precipitation falls here and the dry season is especially severe. Only 226 mm of precipitation falls during eight months of the year, while evaporation reaches more than 2000 mm per year. Conditions of this sort are associated with the highest annual mean and maximum temperatures. The maximum temperature is 42°C in May, and the minimum temperature drops only to +5.2°C in December. The drie tropical savannah has developed here.

North of the valley of the Red River the climate is not as hot and dry. Its characteri tics are exemplified by those of Yuhsi station where much precipitation falls and air tempe ture and evaporation are lower. The maxim temperature measures 34.4°C (May), and the minimum falls to -2.6°C (January). Under t

Table 1

Climatic indexes of the southwestern part of Yunnan province

Stations	Elevation, m	Precipitation			Evaporation			Mean annual relative humidity, %	Average temperatures		
		in millimeters									
		June-Sept.	Oct.-May	annual	June-Sept.	Oct.-May	annual		June-Sept.	Oct.-May	annual
Kumming	1958	785.9	304.3	1090.2	534	1043	1577	—	22.0	13.8	15.7
Yuhsi	approx 1100	578.7	284.7	867.8	611	1294	1905	—	21.9	15.7	17.3
Yüanch'iang	approx 800	547.8	226.8	774.6	889	1128	2017	65	27.7	22.5	24.3
Sze-mao	1390	1058.5	283.2	1341.7	463	1018	1481	82	21.7	16.3	18.1
Chiehli	533	659.9	342.4	999.3	473	990	1463	85	24.8	20.1	21.7
Menghai(Fohai)	approx 800	947.7	484.9	1432.6	—	—	—	—	22.1	18.9	20.0
Nanoshan	1402,6	986.5	468.4	1454.9	424	991	1415	75	21.0	18.0	18.9

conditions savannahs with deciduous trees and pine forests have developed. Still farther north and higher these give way to the Yünnan-Kweichow plateau proper, with its wetter and less warm subtropical climate. The average annual precipitation increases to 1100-1400 mm, and the mean annual temperature drops to 15.7°C. The maximum temperature does not exceed 33°C, and the minimum drops to -5.7°C. In this section the natural vegetation is composed of savannah, pine, and evergreen subtropical forests.

The origin of the savannahs in this region is not clear. Further careful study is needed before we know whether they appeared after forests were cut or whether their development is related to the dryness of the soil resulting from the very fast drainage of the heavily karstic limestones. In spite of the climatic differences, they nevertheless clearly reflect the over-all relative aridity of the whole southern part of the Yünnan-Kweichow plateau as far as the Ai-lao Shan range, and this is also expressed in the soils that are developing here.

South of the Ai-lao Shan range, as shown by the data for the Chiehli, Menghai, and Nanoshan stations (Table 1), the climate is wetter, uniformly warm throughout the year, with a relatively less pronounced dry season, except for Sze-mao. Maximum air temperatures range from 33°C to 38.8°C, and minimum temperatures from +5.4°C (Chiehli) to -3.4°C (Sze-mao).

The data for these stations show a clearly expressed change in climatic conditions with elevation. The tropical monsoon climate (Chiehli and Menghai stations) gives way to a similar subtropical climate (Sze-mao and Nanoshan stations). In this region atmospheric humidity at elevations of 500-800 m (Chiehli) is considerably higher than in the dry subtropical zone (Yüanch'iang). It is characterized both by a greater increase in humidity and a larger decrease in evaporation with elevation than the region considered previously.

The upper boundary of the tropical landscapes does not rise higher than 800 m. Menghai station is located in the transitional zone from the tropical to the subtropical. The elevation interval from 800 m to 1800-2000 m has subtropical monsoon forest landscapes; at higher elevations we find a transition to the more temperate type.

This distribution of climates with elevation shows that within the southwestern sector of Yünnan Province there is not a continuous zone of tropical conditions. They occur as separate "tongues," following the river valleys and adjacent slopes to elevations not exceeding 800 m above sea level. Subtropical landscapes occupy most of this region above 800 m.

This vertical succession of landscapes is associated also with basic regular changes in the vertical zonal distribution of soils, as shown in Figure 2. We find substantial differences between the vertical zonal changes of soils on non-carbonate eluvial parent materials under the dry and moist tropical and subtropical conditions. Only one group of soils recurs here — yellow earths developed under evergreen forests both on recent red weathering crusts and on ancient (residual) lateritized crusts. Under tropical conditions (Profile B) this group occupies large areas, but in the northern subtropics it is found sporadically, being confined

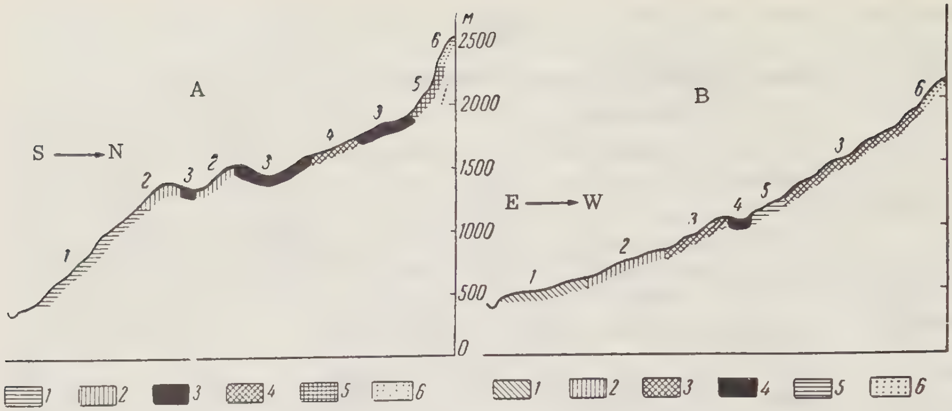

Fig. 2. - Diagrams of the vertical zonal distribution of soils.

Profile A: in the relatively dry subtropical region: 1 - cinnamon-brown-red. Tropical savannahs; 2 - slightly-podzolized red earths. Pine and evergreen subtropical forests; 3 - dark yellow earths (subtropical). Pine and evergreen subtropical forests; 4 - cinnamon-brown-red thin soils of the terra rossa type. Subtropical savannahs; 5 - brown yellow earths. Coniferous-deciduous forests; 6 - high-mountain dark meadow-savannah soils (?). High-mountain meadow savannahs. Profile B: in the moist tropical region. 1 - yellow earths and red earths on lateritized (ancient) weathering crust. Tropical evergreen forests; 2 - the same, on red recent weathering crust of granites. Tropical evergreen forests; 3 - dark subtropical yellow earths on modern weathering crust of granites. Subtropical evergreen forests; 4 - peaty-humic meadow-bog soils. Meadow-bog vegetation; 5 - secondary red earths (post-forest). Secondary meadow savannahs; 6 - brown yellow earths. Evergreen and deciduous forests.

to gentle southern slopes and dry valleys. Various soils have developed on it, from the cinnamon-brown-red savannah soils to the secondary (post-forest) red earths. It should be mentioned that in the tropical area after removing the forests the yellow earths have been developing into secondary red earths in the better-drained areas as a result of the dehydration of iron compounds, which is reddening the soils. This is also promoted by the reduced accumulation of humus in the areas cleared of forests.

In the areas that are not as well drained the removal of the forests has led to the appearance during the rainy season of signs of excess moisture in the surface layer from 20-30 cm. There is clear evidence of spots of gleization, precipitation of iron in the form of concretions and nodules. This indicates that under tropical as well as boreal conditions the clearing of forests can lead to temporary surface swamping with the formation of secondary meadow-savannah soils. But soils of this sort, owing to the wild overgrowth of natural forest vegetation or bamboo, are rapidly redirected toward the restoration of the yellow earth group of soil development, but with certain new traits and properties. The problem of the group nomenclature of the soils is extremely complex. This is particularly true of the segregation of the laterites as a special group of soils developed under tropical and subtropical conditions. We do not think it is possible to separate such a group in China because of the intense allitization of the soil-forming parent materials. Allitization to the same degree occurs in most tropical and subtropical soils. We still have not worked out indexes and methods that are firm enough to divide them into groups and sub groups on the basis of this characteristic. A clearer and more distinct basis is the effect of contemporary accumulation and breakdown of organic materials and the interaction of their products with the allitized soil-forming parent materials. Here, in addition to vegetation, an important factor is the activity of soil organisms, which is reflected not only in the conser sion of organic residues and in the modificatio of the physical properties of the soils, but it also governs the succession of vegetation. The nature and intensity of these processes depend on climatic conditions. The primary importan of bioclimatic factors in the development of th main groups of tropical and subtropical soils is confirmed by the same thing.

This is very clearly brought out in certain properties of yellow earths under evergreen forests (Table 2). Tropical yellow earths, assigned by many investigators to the laterites differ from the subtropical yellow earths in their less acid reaction, their almost unchang and lower content throughout the profile of mobile Al^{+++}, their low accumulation of humus a nitrogen, and their relatively narrow C:N rati

A high accumulation of humus is characteri tic of subtropical yellow earths, reaching alm

Table 2

Change in certain properties of yellow earths as a function of climatic conditions and difference in vegetation

Depth, cm	$\frac{\text{Humus}}{\text{C}}$ in %	N %	C:N	pH, water extract	Exchange acidity	Al^{+++}	H^+	Particle diameter <0.001 mm,%
					after Sokolov meq			
On lateritized ancient weathered crust under humid-tropical forest (Tamulung)[a]								
3—10	$\frac{3.17}{1.84}$	0.21	8.7	5.0	3.11	2.09	0.02	Not det'd.
15—25	$\frac{2.64}{1.54}$	0.14	11.0	5.1	3.11	3.10	0.01	"
30—40	$\frac{2.18}{1.26}$	0.12	10.5	5.1	2.90	2.89	0.01	"
50—60	$\frac{1.96}{1.14}$	0.10	11.4	5.1	2.88	2.87	0.01	"
80—90	$\frac{1.67}{0.97}$	0.09	10.8	5.1	2.80	2.79	0.01	"
On red modern weathering crust under moist subtropical forest (Nanoshan)[b]								
3—8	$\frac{9.87}{5.72}$	0.44	13.0	4.4	3.97	3.85	0.12	27.0
15—22	$\frac{5.72}{3.32}$	0.25	13.2	4.8	3.79	3.68	0.11	32.6
30—45	$\frac{3.38}{1.96}$	0.14	14.0	4.8	3.38	3.28	0.10	35.6
50—65	$\frac{1.01}{0.59}$	0.04	14.6	5.3	2.00	1.90	0.10	35.8
85—100	$\frac{0.72}{0.42}$	—	—	5.2	1.09	1.00	0.09	36.0
On lateritized ancient weathered crust — under secondary growth of bamboo (Tamulung)[a]								
1—3	$\frac{7.24}{4.20}$	0.32	13.1	5.3	1,20	1,16	0,09	Not det'd.
4—10	$\frac{4.24}{2.46}$	0.23	10.6	5.3	1,45	1,42	0,04	"
25—35	$\frac{3.35}{1.94}$	0.17	11.4	5.2	1,30	1,27	0,03	"
50—60	$\frac{2.64}{1.53}$	0.12	12.8	5.1	1,10	1,08	0,03	"
100—110	$\frac{1.78}{1.03}$	—	—	5.2	0,95	0,94	0,02	"

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[a] Data of the Tamulung biogeocenotic station. Analysts: Kang-liang, Wang Fu-hai, U Mieh-ling.

[b] Data of the Soil Institute of the Academy of Sciences of China, kindly supplied by soil scientist Chou Ch'i-kuo.

10% in the A_1 horizon. Their humus is more acid, judging from the low pH in the upper layer. The higher exchange acidity is determined by this as well as the greater mobility of Al^{+++} to a depth of 45-50 cm. In the same layer there is a pronounced removal of clay separates, possibly because of the high mobility of the iron colloids. The layer below 45-50 cm is less acid in reaction, has less available Al^{+++}, and smaller values of exchange acidity than in tropical yellow-earth. If we admit that these properties are governed by the lower allitization of the mineral portion of the subtropical yellow earths, then its higher value in the surface humus layer is related to the effect of the more acid mobile humic substances. This may indicate that, under present conditions of soil formation, allitization is associated to a large extent with the decomposition products of organic material and the accumulation of humus.

The more allitized ancient lateritic weathering crust has a very small effect on present processes of soil development. The greater accumulation of humus in soils under subtropical forests than under tropical forests permits us to say that in the latter mineralization is more pronounced, while in the subtropical types the breakdown of organic material is the predominant process.

A general property of yellow earths is the high iron content, principally as hydrated compounds; this is also responsible for the distinct yellow color of these soils.

The qualitative difference in the processes of humus accumulation in tropical and subtropical soils leads to differences in acidity, mobility of Al^{+++}, and the redistribution of the clay fractions in the soils. All this confirms the thesis that present biological processes are more important in the soil formation than the degree of allitization of the mineral part of the soil. We cannot but stress that under present conditions allitization rather depends on the qualitative differences in the processes that determine the development of the various genetic soil groups.

Substantial changes in soil formation under tropical conditions and particularly under subtropical conditions in regions with vast formation of limestone. The effect of limestones is expressed both directly in the clay eluvium that forms as they weather and indirectly, in the enriched bicarbonate content of surface and percolation flow from the upper parts of slopes composed of limestones. At the same time there is the familiar secondary saturation of the soil with calcium. Finally, the effect of climatic conditions on the weathering of limestones is no less important. Thus, under dry primary savannah conditions their weathering products are covered in places with red soil of the terra rossa group and cinnamon-brown-red soils, but under moist tropical and subtropical conditions we find residual leached or secondar saturated yellow earths.

Such differences in the development and vertical zonal distribution of soils associated with limestones are shown in Figure 3. Profile A exemplifies the typical development and succession of soils in the Mengleng region (eastern part around Hsishangpang), and Profile B, on the southern slope of the Red River valley along the road from the city of Kiehchin to T'ing p'ing The essential difference in the soils is shown by the data on their pH variations.[3] Thus, in Profile A, where the soils have developed on an eluvium of non-calcareous shales and are irrigated by water that is acid or neutral (880 m elevation), the pH varies as follows: 1 cm, 5.5 20 cm, 5.4; and 50 cm, 4.8. Under the same conditions, but with irrigation by waters containing bicarbonates, (elevation 740 m), we find: 2 cm, 6.5; 10 cm, 6.4, 25 cm, 5.8; and 45 cm, 5.8. Where the soils have developed on clay limestone eluvium and are irrigated by water containing bicarbonates (1290 m elevation), the pH values are as follows: 2 cm, 7.2; 10 cm, 6.6; 30 cm, 6.6; 50 cm, 6.7; 75 cm, 6.7; and 106 cm, 6.8.

A similar relationship was also found in the soils of Profile B, where, on residual limestone eluvium of the terra rosa (elevation 280 m) group the pH varies with depth in the following manner; 5 cm, 6.5; 20 cm, 6.5; 75 cm, 6.0; 100 cm, 6.0 and 200 cm, 7.0. But at 1340 cm, where the soil is highly leached, but where the surface water contains bicarbonates, the pH varies in the opposite direction: 3 cm, 6.5; 18 cm, 6.2; 40 cm, 6.2; 75 cm, 5.5; and 120 cm, 5.5.

In contrast to the eluvium of non-calcareous rock, limestone eluvium evidently has a more clayey-siallitic or allitic character. Soils developed on them, as pointed out earlier, contain in their upper horizons abundant iron concretions resulting from precipitation of iron in the pores of the neutral or weakly alkaline medium. Very often at elevations about 1000 m the soils have a well-defined, granular, dark humic A horizon, which permits us to assign them to the subgroup of humic-yellow earths. Additional analytical study of these soils undoubtedly will permit us also to establish other distinguishing characteristics for them.

Thus, the effect of limestone on soil development is very distinct and to a certain extent similar to that observed in soils of the forest regions of more temperate latitudes.

No less complex, varied, and vigorous is th

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[3] We still do not have available the other analytical data, since processing of the soil collections has only begun.

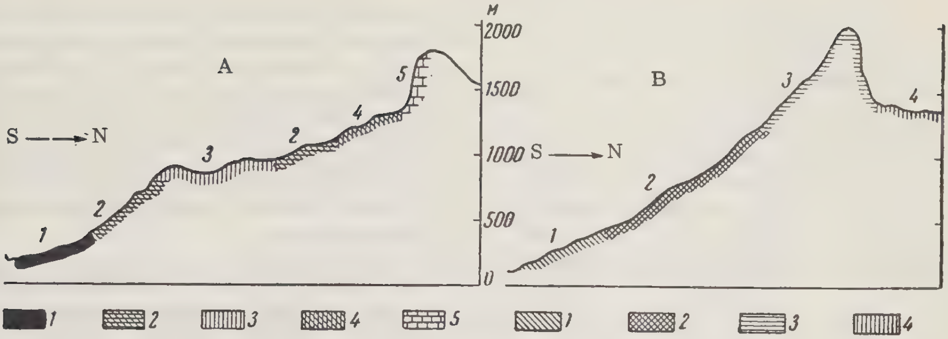

Fig. 3. - Diagram of vertical zonal distribution of soils developed under the influence of limestones.

Profile A: - in moist-tropical region. 1 - rice soils; rice fields. 2 - secondarily saturated zheltozems on eluvium of non-calcareous shales; tropical evergreen forest; 3 - surface-gleyed zheltozems; secondary savannahs. 4 - humic zheltozems secondarily saturated on clayey sialite of limestone eluvium; subtropical evergreen forest. 5 - limestone outcrops.

Profile B: - in savannah of tropical region. 1 - cinnamon-brown-red and terra rossa; tropical savannahs; 2 - cinnamon-brown-red, low in humus; tropical savannahs; 3 - low-humus zheltozems on limestones; subtropical forest. 4 - zheltozems, slight secondary saturation.

ffect of different types of vegetation on the oil. Let us look at data (Table 2) showing the hanges in tropical yellow earths as a result f cutting moist evergreen forests and their eplacement with bamboo. Under the bamboo he yellow earth is enriched in humus and nirogen, the pH rises, and there is a considerble decline in the exchange acidity and the ontent of available Al^{+++}.

There is a marked improvement in the soil nder the bamboo. This is primarily associted with the fact that the bamboo litter is less cid (pH 6.5), while the pH of the litter of the noist tropical forest is only 5.3. The amount f litter in January 1959 was 1006.8 kg/ha in he bamboo forest, and 472.9 kg/ha in the moist ropical forest.

Still more striking was the amount of CO_2 iberated from the surface of the soil, as meaured in the same month:

Moist tropical forest	0.953 kg/hr-ha
Bamboo thickets	1.760 kg/hr-ha
Herbaceous vegetation in a clearing	1.337 kg/hr-ha

The content and distribution of CO_2 in the oil atmosphere agrees with these figures to certain degree (Table 3).

Table 3

CO_2 content in the soil atmosphere of tropical soils under various vegetation in January 1959, % by volume

Depth, cm	Moist tropical forest	Bamboo	Herbaceous vegetation, clearing
10	0.60	1.00	0.80
20	0.80	2.60	1.50
40	1.40	2.80	1.40
60	1.90	1.80	2.10
100	2.02	3.40	1.40
150	3.40	4.60	3.15
200	4.00	6.00	2.40

They show that in the dry season the decomosition and mineralization of the litter is more ntense under the bamboo than under the moist ropical forest. At the same time a considerble quantity of CO_2 enters the soils and "tricels" into the deep horizons. This is probably related to the higher relative humidity and stagnation of the air under the forest than under the herbaceous vegetation. Under the latter we find rather an evolution of the CO_2 from the soil; the content in the lower horizons declines rapidly as compared with soils under other types of vegetation. It should be pointed out that the cleared area was created artificially by cutting all trees and shrubby growth a month after the beginning of the observations.[4] The moisture contents in the soils in January are also different, as we see from the following data (Table 4).

In the first place, they give us an idea of the

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[4] All woody residue and litter were carefully removed.

Table 4

Moisture contents under various vegetation in January 1959, mm

Depth, cm	Moist tropical forest	Bamboo
0– 50	165.3	191.4
50–100	161.9	172.4
100–150	163.2	159.7
0–150	490.4	523.5

moisture content of the tropical yellow earths in the dry season, and in the second place, they show us that the soils dry out somewhat more under the moist tropical forests than under bamboo, a fact which is of some significance for an understanding of the annual dynamics of the soil processes.

The comparative data cited, which describe the effect of the individual types of vegetation on the characteristics of, and processes occurring in, the tropical yellow earths, were obtained at the first biogeocenotic station for the study of tropical forests and their interaction with the principal components of the environment. This station was organized by the Academy of Sciences of China at Tamulung village in the southern part of the autonomous region of Hsishangpang on the Burma border. The Forest Science Laboratory of the Academy of Sciences of the USSR has taken a very active part in its organization and in providing scientific and methodological guidance, while the author of this paper, cooperatively is directing the study of the dynamics of soil processes.

The significance of the studies of soil processes that have been undertaken at this station is great and they are important for explaining not only the role of vegetation but also the genesis of tropical soils. All this is done with the intention that after two or three years the soil scientists of China will have very valuable data on th nature of the processes that determine the development of tropical soils, and this will permi a reasonable solution of the disputed and unclear problems of classification of the unusual tropical and subtropical soils of China.

In conclusion I wish to thank the soil scientist Chou Ch'ikuo, who has been very helpful in the conduct of the work, and to Professor Li Chang-kwei and Huo Kung-t'ing for their counsel and active solution of many debatable questions.

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MINEROLOGICAL COMPOSITION OF KRASNOZEMS DEVELOPED ON THE ELUVIUM OF IGNEOUS ROCKS

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Krasnozems are widely distributed and agriculturally very valuable soils of the subtropics. They are extensively used for farming in the People's Republic of China and in the USSR. The fertility of krasnozems depends closely on their chemical and mineralogical composition. The mineralogical content and composition depend in turn on the basic factors of soil formation.

There are many papers devoted to the study of the mineralogical composition of krasnozems (1, 2, 3, 4, 5, 7, 8, 9, 10, 11-14), but very little data on the mineralogical composition of the various fractions of these soils formed on different rocks, and even less data from the application of a combination of methods.

This paper presents the results of studies on krasnozems developed on the eluvium of granite and andesite-basalt. Since it is difficult to find krasnozems on different rocks in the same area, we took samples of soils on granite in Kiangsi province of the People's Republic of China[1] and on andesite-basalt from the Chakaya area of the Georgian SSR.

These areas are somewhat similar climatically even though Chakva lies at latitude 41°-45' and Kiangsi at latitudes 25°-30°. The average annual temperature in Kiangsi is about 18°C, and in Chakva, 17°C. Precipitation according to the data of the meteorological station of Kiangsi province amounts to about 1800 mm, and in the Chakva area, about 2200 mm.

Thus both areas belong to the humid subtropics, where there is intense conversion of primary to secondary minerals. Both granites and andesite-basalts are ancient rocks, and the formation of highly disperse minerals from them takes a very long time, extending even to the present.

The soil-forming parent rocks of both krasnozems differ markedly from each other in mineralogical composition; hence their rates of weathering differ. Granites consist chiefly of feldspars (orthoclase), muscovite, and quartz; the andesite-basalts, of feldspars (plagioclases), dark-colored micas, and a small amount of quartz. In addition, both rocks contain small quantities other minerals. As a result of this difference in composition, the granites weather appreciably slower than the andesite-basalts, and this is expressed in the speed of formation of highly disperse soil particles, and hence in the quantity of secondary minerals that accumulate in them.

We see from Table 1, where the particle-size analysis is given, that the particles >0.25 mm in diameter in krasnozem on granite exceed 28% while in krasnozem on andesite-basalt they are no more than 4%. Correspondingly the content of particles <0.001 mm in diameter in the first soil varies from 13%-24%, and in the second, from 19%-44%. The accumulation of an appreciable quantity of fine particles in krasnozem on andesite-basalt is obviously explained by faster weathering of the rock under the action of climatic and biological factors. For the same reason there is a big difference also in the chemical composition of the rocks and the soils formed on them (Table 2). In the soil on granite there is considerably more silica and potassium than in the soil on andesite-basalt. The $SiO_2:R_2O_3$ ratio in the first soil is larger than four; in the second, about two. To determine their mineralogical composition, both soils were subjected to thermal, X-ray and electron-microscope study as well as chemical analysis.

First, the thermal analysis was carried out on the soils as a whole, and then on the fractions <0.001 mm in diameter and the coarser fractions. Let us consider first the thermo-

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[1] Krasnozem samples from Kiangsi were furnished by Chinese soil scientists with the cooperation of S.A. Shuvalov.

Table 1

Particle-size analysis (dispersion) of krasmozems, percents

Soil	Depth, cm	Diameter of fractions, mm						
		>0.25	0.25–0.10	0.10–0.01	0.01–0.005	0.005–0.001	<0.001	<0.01
Krasnozem on granite	5–15	28.77	4.27	24.40	5.39	12.40	24.86	42.56
	40–55	28.70	4.49	32.57	5.54	9.04	19.66	34.24
	80–90	32.93	5.30	39.57	3.01	5.68	13.51	22.16
Krasnozem on andesite-basalt	0–20	3.97	2.53	30.26	10.08	18.27	34.89	63.24
	40–50	1.05	1.55	25.30	8.48	19.13	44.49	72.10
	100	2.05	4.71	47.83	12.03	13.74	19.64	45.10

Table 2

Total chemical composition of soils separated from their < 0. 001 mm diameter fractions percents on ignition bases, pH, and cation adsorption capacity

Soil	Depth, cm	SiO_2	Al_2O_3	Fe_2O_3	R_2O_3	CaO	MgO	K_2O	Na_2O	$\frac{SiO_2}{R_2O_3}$	pH		Cation adsorption capacity, meq/100
											H_2O	KCl	
		Whole soil											
Krasnozem on granite eluvium	5–15	67.39	19.72	7.98	27.70	0.35	0.72	2.05	0.14	4.61	5.02	4.28	4.41
	40–45	65.99	22.02	7.92	29.94	0.31	0.58	2.05	0.11	4.14	5.06	4.20	4.38
	80–90	65.58	20.49	8.30	28.79	0.44	0.69	1.92	1.12	4.36	4.92	4.14	3.42
		Fraction < 0. 001 mm in diameter											
The same	5–15	42.41	35.49	18.62	54.11	0.50	1.21	1.26	0.07	1.51	—	—	12.31
	40–45	40.62	33.32	22.96	56.28	1.04	0.96	1.21	0.09	1.44	—	—	10.88
	80–90	42.14	29.52	23.73	53.25	0.46	0.80	1.20	0.07	1.60	—	—	9.48
		Whole soil											
Krasnozem on andesite-basalt eluvium	0–20	50.26	26.55	19.20	45.75	1.55	1.85	0.67	0.14	2.20	4.73	4.47	Not det'd.
	40–50	50.00	29.30	19.29	48.59	0.84	0.75	0.33	0.04	2.04	4.77	4.40	"
	100	51.67	31.49	15.36	46.85	0.38	0.64	0.46	0.18	2.12	4.94	4.50	"
		Fraction < 0. 001 mm in diameter											
The same	0–20	42.88	33.50	20.70	54.20	0.76	0.58	0.62	0.07	1.56	—	—	20.84
	40–50	42.80	30.11	22.78	52.89	1.31	1.14	0.34	0.05	1.63	—	—	18.39
	100	42.10	33.75	21.80	52.55	0.59	0.65	0.27	0.17	1.50	—	—	20.29

gram of the whole soils (Fig. 1).

In all thermograms we see endothermic effects with maxima at 70°-135°C and 525°-565°C, and exothermic effects with maxima at 940°-970°C. In addition, on some thermograms there are exothermic effects at 275°C from the burning of organic materials, and endothermic effects at 250°-300°C from the presence of goethite and gibbsite.

The endothermic effects at 70°-135°C indicate the amount of hygroscopic moisture in the soils. As we see from the thermograms, the amount of this in the Chakva krasnozem is larger than in the krasnozem is larger than in the krasnozem from Kiangsi. The endothermal effects at 525°-565°C and the exothermic effects at 940°-970°C, from the size and sharp peak of the heating curves, indicate a high content in both soils of minerals of the kaolinitic group — kaolinite and halloysite. But none of them is in the krasnozem on andesite-basalt, a fact attested by the magnitude of the effects at 525°-565°C. In the first soil there is slightly more of sesquioxide minerals (probably goethite and gibbsite), which may be inferred from the effects at 270°-300°C. In the kras-

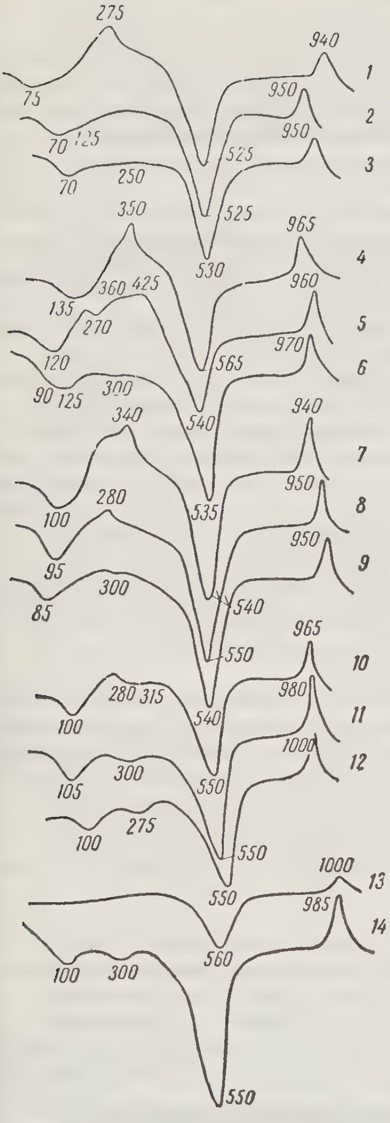

Fig. 1. - Thermograms of whole krasnozems and of fractions separated from them.

1, 2, 3 - Krasnozem on granite, whole soil (depth 5-15, 40-55, and 80-90 cm); 4, 5, 6 - Krasnozem on andesite-basalt, whole soil (depth 0-20, 40-50, and 100 cm); 7, 8, 9 - Fraction<0.001 mm in diameter from krasnozem on granite (depth 5-15, 40-55, and 80-90 cm); 10, 11, 12 - Fraction<0.001 mm in diameter from krasnozem on andesite-basalt (depth 0-20, 40-55, and 100 cm); 13 - 0.10-0.01 mm diameter particles separated from krasnozem on granite (depth 40-50 cm); 14 - 0.10-0.01 mm diameter particles separated from krasnozem on andesite-basalt (depth 100 cm).

nosem from Kiangsi these minerals are found in quantities below the sensitivity of the method. The presence of sesquioxide minerals in the Chakva krasnozem is explained by the intense conversion of primary into secondary minerals and the relatively high content of non-silicate iron and aluminum. Silica, released from aluminosilicates and from rapidly mineralized plant residues, is partly leached with water. The intensity of this process is increased by the large amount of precipitation in the subtropical zone, and the leaching water regime of these soils. The mineralogical and chemical composition of the krasnozems indicate appreciable desilication of the soil-forming parent material, which is not observed in sod-podzolic soils.

If we compare the thermograms of the particles <0.001 mm in diameter separated from the soils, it is not difficult to detect traces of similarity and difference in them. The similarity is this: minerals of the kaolinite group predominate in these fractions of both soils. This is attested by the large endothermal effects at 540° and 550°C and the exothermal effects at 940°-1000°C. The endothermal effects at 85°-100°C are slightly higher in the finer fraction of soil developed on granite. And the difference is this: the highly dispersed minerals of the krasnozem on andesite-basalt contain appreciable amounts of sesquioxide minerals, as shown by the effects at 275°-315°C, while the amounts of these minerals in the krasnozem on granite is very small. Thus the hardly noticeable difference in the whole soils becomes clearer in the thermograms of the fine fractions <0.001 mm.

This conclusion is confirmed by data from total chemical analysis of the particle diameters <0.001 mm (Table 2). Their chemical composition is similar; the $SiO_2:R_2O_3$ ratio in both cases is less than two and varies within small limits. But an appreciable difference is observed in the potassium content, which was to be expected, since there is more mica in the granite than in andesite-basalt and its degree of weathering is less. Micas and hydromicas probably have remained in the granite, and, as is well-known, their potassium content reaches 5%-6%. In the krasnozem on andesite-basalt almost all the hydromicas have reached stages of kaolinization, and potassium, as a very mobile element, has been removed.

In the clay fraction of the soils the minerals of the kaolinitic group (kaolinite, halloysite) and the admixture of minerals that have no exchange capacity (goethite, gibbsite, quartz) were predominant. The cation exchange capacity does not exceed 5 meq/100 g of soil and 20 meq/100 g of the clay fraction, while the adsorption capacity for the clay fraction of krasnozem on granite is less. This difference is probably explained by an equal ratio of halloysite and kaolinite. The first has a higher cation adsorption capacity than the second.

The thermograms of the coarse fractions, i. e., >0.001 mm in diameter (Fig. 1), are of considerable interest. Because of the similarity of the data obtained we give thermograms only for the 0.1-0.01 mm diameter fractions, although studies were made also for the 0.01-0.005 mm and 0.005-0.001 mm diameters. As is apparent from the thermograms, the 0.1-0.01 mm diameter fractions contain a considerable quantity of kaolinite, which is much less in the krasnozem on granite than in the krasnozem on andesite-basalt. The endothermic effect at a temperature near 300°C attests to the presence in the latter of sesquioxide minerals. We should also note the presence on the thermogram of the effect at 100°C, which indicates the highly hydrophilic nature of the coarse fraction of the Chakva krasnozem. The presence of minerals of the kaolinite group in the coarse fractions, and moreover in appreciable amounts, was observed by us in soils of the subtropical zone. This was not observed in other soils. This characteristic results from several causes: 1) the highly weathered condition of almost all primary minerals, except quartz, and their conversion into secondary minerals; 2) the large size of the aggregates and crystals. We were led to the latter conclusion by the fact that minerals of the kaolinite group were observed not only in the clay but also in the coarser fraction.

To determine more precisely the mineralogical composition of the highly dispersed part of the soils, the colloidal fraction was studied with the electron microscope. These studies showed that both soils contain principally fragmented crystals of kaolinite and halloysite (Fig. 2, a and b). The major portion of the mineral fragments are <0.2 μ in diameter. Both soils also contain whole rod-shaped crystals of halloysite; they are few in the krasnozem on granite but very abundant in the krasnozem on andesite-basalt. The shape of the halloysite crystals is also slightly different: in the krasnozem on granite the rods of halloysite are longer than in the krasnozem on andesite-basalt. On the electron micrographs, in addition to the crystals of the kaolinitic group, plates of mica are also encountered.

Interesting conclusions were reached from X-ray analysis. Studies were made of the fraction <0.001 mm in diameter before and after saturation of the oriented aggregates with ethylene glycol as well as before and after heating of the samples of 600°C (Table 3). All X-ray patterns showed reflections characteristic of kaolinite: 7.08-7.46 kX; 3.57-3.69 kX; 2.33-2.38 kX which are indexed as 0.01, 0.02, and 0.03. Thus the conclusion reached on the basis of thermal and chemical analysis is confirmed. Moreover the following additional conclusions can be drawn. On all X-ray patterns, reflections at about 10 kX were observed. These reflections may be ascribed either to a mineral or the kaolinite group — halloysite, or to hydromicas; and sometimes they appear, as special investigations have shown (4), as the result of the high dispersion of kaolinite.

After heating of the sample this line and the lines of kaolinite disappeared, and the goethite lines became brighter. Hence we may conclude that the reflection at 10 kX resulted principally from halloysite. The hydromicas, if also present, are present in small amounts. This can be judged from the potassium content, which constitutes slightly more than 1% of the clay fraction of the soil on granite.

All the X-ray patterns showed a marked dark background probably caused by the presence of goethite, gibbsite, and amorphous hydroxides of iron and partly of aluminum. The total number of reflections on the X-ray pattern of the krasnozem on andesite-basalt

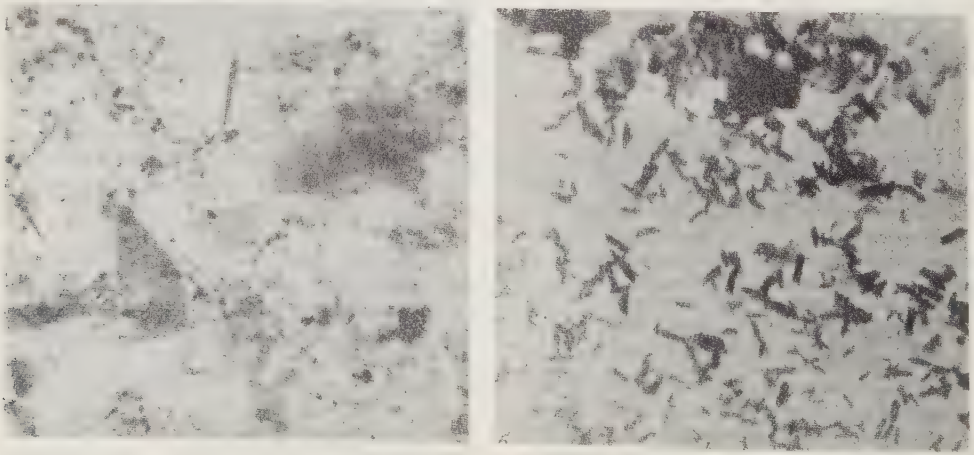

Fig. 2. - Electron micrographs of the colloidal fraction of krasnozems (X 12,000).
a - on granite b - on andesite-basalt

Table 3

X-ray data for fractions <0.001 mm separated from Krasnozems formed on various igneous rocks (oriented aggregates saturated with ethylene glycol).

Krasnozem on andesite-basalt						Krasnozem on granite					
Depth in cm											
0–20		40–50		100		5–15		40–55		80–90	
kX	I	kX	I	kX	I	kX	I	kX	I	kX	I
10.6	6^d	10.4	7^d	12.7 10.6	8^d	10.8	10^d	10.6	4^d	10.8	9^d
7.47	8^d	7.42	6^d	7.26	1	7.08	10	7.08	10	7.28	10
						4.91	4			4.91	1
4.56 4.34	10	4.31 4.04	8^d	4.41	9	4.48	10	4.41 3.94	1m	4.57	9
				4.13	8	4.20	8			4.27	8
3.61	8	3.57	10	3.47	9	3.57	10	3.57	10	3.69	10
						3.34	3	3.34	2	3.38	3
						3.22	2				
						2.97	3				
						2.7002	7	2.702	1	2.759	5
2.598	7	2.585	4	2.550	8	2.598 2.504	8	2.598 2.504	5	2.598 2.504	7
		2.415	2	2.438	6_r	2.552 2.438	5				
2.383	7	2.359	3	2.335	8	2.334	8	2.334	2	2.375	4
						—		—		—	
						2.188	7^d	2.205	2^d	2.224	2^d
				2.005	3	2.005	6	2.004	3^d	2.033	2^d
						1.853	2^d	1.853	1^d	1.853	1
1.740 1.660	7^d	1.716	3^d	1.706	8	1.786	2^d	1.800	1^d	1.745	5
				1.651	3	1.706	8^d	1.706	3d		
						1.652	8^d	1.642	2d	1.652	10^d
1.512	10	1.505	10	1.491	10	1.498	10	1.484 1.478	4	1.505	10
						1.446	6				
						1.357	5				
						1.318	7				

was less than on the X-ray pattern of the krasnozem on granite. This phenomenon is a result of the following. The primary minerals in the krasnozem on granite were partially preserved and gave their reflection. Among the primary minerals there was a particularly high content of quartz (reflections at 4.20, 3.34 kX, etc.). There is very little quartz in the andesite-basalt, and for this reason the X-ray patterns of the clay fraction do not show quartz reflections. Many of the lines are vague; this indicates the high dispersion of the crystals of the clay minerals. This conclusion agrees with the data from the electron micrographs, which show very few entire crystals of kaolinite.

Conclusions

1. Krasnozems developed on eluvium of granite and andesite-basalt show in their mineralogical composition features of similarity and difference. The similarity lies in the fact that the highly disperse portion (<0.001 mm in diameter) of both soils consists chiefly of minerals of the kaolinitic group. The difference lies in the fact that the krasnozem on andesite-basalt contains an appreciable amount of sesquioxide minerals (goethite, gibbsite), while these minerals in the krasnozem on granite are absent or present in insignificant quantities.

2. Minerals of the kaolinitic group are found in significant quantities also in the coarser (than clay) fractions up to 0.1 mm in diameter; in the krasnozem on andesite-basalt there are more of the clay minerals than in the krasnozem on granite. This is explained by the presence of quartz in granite. Quartz has persisted in its weathering products, and also by the slower weathering of this rock.

3. The chemical composition of granites and andesite-basalts is markedly different, while the clay fractions of krasnozems developed

on these parent rocks are more similar in composition. The difference consists in the higher content of potassium in the clay fraction of the krasnozem on granite. The presence of potassium indicates the younger age of these soils (in the sense of duration of weathering of the parent material) and the presence of a certain amount of hydromicas.

4. Owing to the difference of the parent materials the texture of the krasnozem on granite is coarser than the krasnozem on andesite-basalt.

5. The cation adsorption capacity of the krasnozem and the fractions <0.001 mm in diameter removed from them is fairly low. This is explained by the predominance of minerals of the kaolinitic group and the presence of free sesquioxides, and also by the presence of quartz in the soils on granite.

6. The mineralogical composition of the krasnozems and fractions <0.001 mm in diameter separated from them is controlled by different factors; the major role in this respect is played by the parent rock.

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CHARACTERISTICS OF THE PHYSICAL PROPERTIES, WATER AND TEMPERATURE OF KRASNOYARSK FOREST-STEPPE SOILS

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In spite of the long agricultural history and the enormous possibilities for further land reclamation, the soils of the Krasnoyarsk forest-steppe have been studied very little. A general deficiency of the data on these soils, as well as soils of other regions of Central Siberia, is the almost complete lack of information on their physical properties, and their water and temperature (3).

In the first stages of investigation it became clear that these soils are of a special nature as far as their moisture, freezing and warming are concerned, as compared to similar soils in the European part of the USSR. Only by studying these problems is it possible to understand the processes of soil formation and to establish proper agricultural measures for these soils. Therefore, parallel with the study of the chemical and physical properties of soils, the question arose as to the study of their water and temperature, which was done by us.

Three representative key areas were selected under the typical soil and geomorphological conditions of the Krasnoyarsk forest-steppe and adjacent sub-taiga, with predominant soil groups. The first area was in the central part of the forest-steppe (Sukhobuzimskiy State Experiment Station, 65 km north of Krasnoyarsk) on a leached chernozem (10%-11% humus, and 40-45 meq of adsorbed cations); the second, a sub-taiga area near Talovka village in Bol'she-Murtinskiy district, 148 km north of Krasnoyarsk, with gray and dark-gray forest gley soils (8%-9% humus, 32-36 meq of adsorbed cations, and a pH of the salt extract of 6.0-6.2); and the third, in the northern part of the sub-taiga near Kazachinskaya sovkhoz station 200 km north of Krasnoyarsk, with sod-podzolic soils (3.5%-4% humus, 18-20 meq of adsorbed cations, and a pH of the salt extract of 5.0-5.5).

Investigations were conducted in each of the key areas on two adjacent plots: an old plowed area and virgin soil (sparsely wooded and forest). Observations on soil moisture and temperature were made to a depth of 4-8 m every 10-15 days between May and October in 1957 and 1958. Three soil moisture holes were taken, replicated twice for every 10-cm layer to a depth of 1 m, and every 20-cm layer at greater depths. The temperatures were measured in the holes taken for moisture with deep soil thermometers at the following depths: 10, 20, 40, 60, 80, 120, 160, 200, 260, 320, 400, 500, 600, 700, and 800 cm. Soil freezing and thawing were determined by periodically excavating pits, by direct examination of core samples, and from thermometer readings.

The physical and moisture characteristics of the soils were studied by standard methods in the field and in the laboratory.

This article outlines only some of the most important physical properties of these soils and their water and thermal regime.

Physical Properties

The key areas studied have generally a sloping rolling topography with micro-depressions everywhere. The parent material consists primarily of yellowish-brown loess-like clay loam, and light-brown and dark-brown clay to silty coarse clay loam. They are underlain at depths of 4-5 or 8-10 m by sandy-gravelly deposits. The water table is located below 10-15 m.

The texture of the soils studied is fairly uniform along the profile (Fig. 1), with large amounts of coarse silt particles (25%-40%) and a small amount of fine sand (10%-15%). The clay content is 25%-40%. Such texture lends a loess-like character to the soils.

However, the soils differ greatly in their micro- and macrostructure. Leached chernozem (Sukhobuzimskiy State Experiment Station, profile 43) has a poorly defined macrostructure (20% of the particles >0.25 mm in diameter), in spite of the fact that the soil had two sequences of grass rotation. The leached chernozem appears to be dispersed, but actually it is easily cultivated and puddles slightly; it is loose and has a fair water permeability (3.9 mm/min). This may be explained by its agronomically valuable microstructure: 60% particles >0.05 mm in diameter, and a dispersion coefficient of 8.1.

Gray forest soils (in particular, dark-gray forest soil and plowed soil, profile 41) possess a good blocky to granular structure, or macrostructure with more than 58% particles >0.25 mm in diameter. But their microstructure is less clearly defined (about 40% particles >0.05 mm in diameter) than in leached chernozem. The dispersion coefficient is 8.1. Their good macrostructure places these soils, according to their water and air permeability, in the category of highly fertile soils.

Sod-podzolic soils (Kazachinskaya agricultural station, plowed soil, profile 46) have a cloddy surface, low water permeability (0.33 mm/min), become strongly compacted, and puddled, in spite of the fact that they had undergone four grass rotations. They have a poorly defined macrostructure (less than 10% particles >0.25 mm in diameter) and microstructure (less than 30% particles >0.25 mm in diameter), both these values being two times lower than in the chernozem. The dispersion coefficient is 14.1. It must be concluded that the sowing of grass alone cannot produce the agronomically required structure in these soils. An addition of lime appears to be greatly needed. Besides, to improve the humification of plant remnants, the soil must be periodically cultivated deeply.

Figure 1 shows that all the soils studied have good moisture characteristics. With a comparatively high content of firmly bound water (maximum hygroscopicity (MH) of 8%-12%, and a wilting moisture (WM) of 14%-20% by soil volume), the soils have a high minimum moisture capacity (MM), of the order of 32%-38% by soil volume. Thus the range of active moisture (MM-WM = RAM), which is the ultimate index of moisture and physical characteristics, equals 18%-20% by soil volume, or 182-188 mm of water available to plants in the upper 1 m of all soils, and 360-381 mm in the upper 2 m. Thus soils are capable of accumulating an amount of moisture in a form available to plants equal to the total annual precipitation. It must be noted that such narrow RAM indexes for various soil groups emphasize again the direct dependence of RAM on texture, which is almost identical for all soils. As far as the air content in the 50-cm soil layer occupied by plant roots is concerned, the soils differ greatly. With a moisture content equal to the MM, dark-gray soils contain 27% air, chernozem, 15.1%, and sod-podzolic soil 10.7%. An almost ideal combination of phases is found in the dark-gray forest soil: solid 40%-45%, liquid 30%-35%, and gaseous 27%.

Water intake rate for plowed chernozem and gray forest soils is 250-300 mm in the first hour, and for sod-podzolic soils, 20 mm. According to the approximate scale of Kachinskiy (6), the water intake of the first two soils is good, and that of the last soil is unsatisfactory. Consequently, rainfall is fully absorbed in the first case, while in the last, rainfall ofte causes soil erosion. The water permeability of illuvial layers and of the parent material is 2-5 cm/24 hr, whereby illuvial layers have the lesser water permeability. The comparatively good water permeability and low bulk density (about 1.3-1.5) of illuvial layers may be explai by fissuring and loosening by deep freezing. This considerably decreases the unfavorable effect of gley, found everywhere from a depth of 70-100 cm, on the physical properties of soils, in particular their drainage.

Surface water, which sometimes accumulates in plowed sub-taiga areas in May-June after heavy precipitation in autumn and in earl spring after soil thawing has begun, is caused by the slow thawing of the frozen layer. As the soil thaws, the level of the surface water drops, and the water disappears entirely 1-2 weeks after the soil has thawed completely. Surface water delays the initial field work, but later, after sowing, the fact that it remains at a depth of 70-100 cm is an important factor in the moisture supply to plants, especia ly at the onset of the dry period. Therefore it is extremely important to develop methods for converting surface runoff into subsoil, especia ly in sod-podzolic soil.

The physical properties of chernozem and of gray forest soils as a whole may be considered entirely satisfactory, not needing any meliorative agricultural measures. As it can be seen from the example of leached chernozem, the lack of a blocky to granular structure does not necessarily impair its physical prope ties. In this respect Kachinskiy has rightly stated that "being stable, the microstructural aggregates partly assume the role of coarse elements and, in this sense, improve the physi cal properties of fine-textured soils, as though transforming them into a coarser-textured soil It must be added that with microaggregation fi textured soils do not assume such unfavorable properties of coarse-textured soils as a reduced range of active moisture.

Soil Temperature

The markedly continental climatic conditions of the Krasnoyarsk forest-steppe create a specific soil climate, which lends certain peculiarities to some of its important agronom cal properties. The mean long-period air tem perature in the forest-steppe and sub-taiga zo

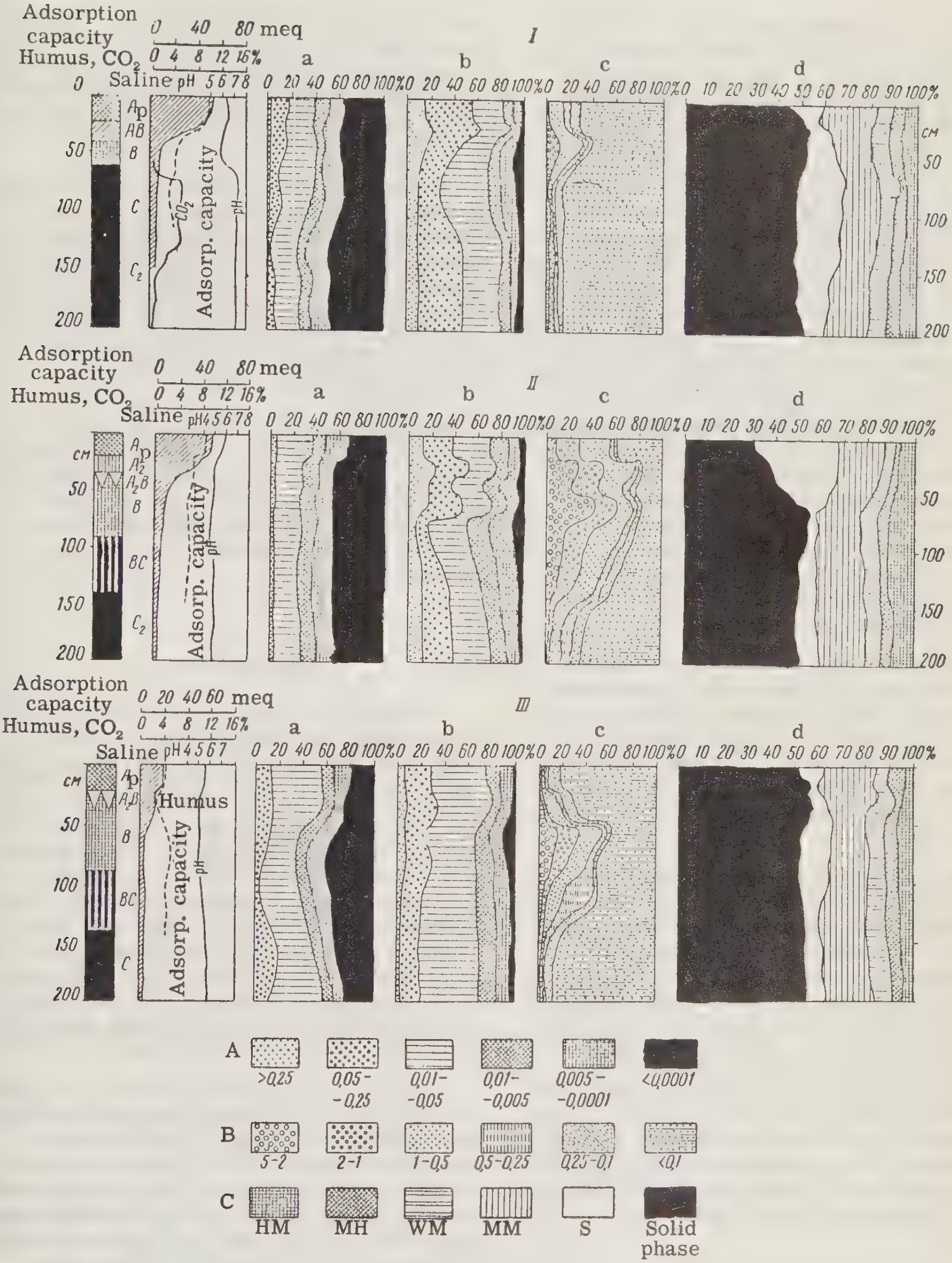

Fig. 1. - Physical and moisture characteristics.

I - leached chernozem, plowed area, profile 43; II - dark-gray forest soil, plowed area, profile 41; III - sod-podzolic soil, plowed area, profile 46.
a - texture; b - microaggregates; c - macroaggregates; d - moisture characteristics;
A - Diameter of particles and microaggregates, mm; B - Diameter of macroaggregates, mm;
C - moisture characteristics.

s -1.7-1.8°C, with a mean temperature of 16.8°C to -20.6°C in January and +18.2°C to 17.5°C in July. The duration of the period with air temperatures above 0°C is 189 days n the forest-steppe and 175 days in the sub-taiga. The period of continuously very low temperatures in winter causes prolonged and deep soil freezing to a depth of 280 cm in the forest-steppe and 115 cm in the sub-taiga. In individual years, freezing reaches a depth of 360 cm in the forest-steppe and 200 cm in the sub-taiga. The soil thaws completely in August in the forest-steppe and in early June in the sub-taiga. A soil temperature higher than + 10°C lasts for 90-100 days (from late May to early September); this temperature reaches a depth up to 100-120 cm in plowed chernozem of the forest-steppe, and 140-160 cm in gray forest and sod-podzolic soils of the sub-taiga. The mean annual temperature of the soil profile in the forest-steppe (+2.7°C) is considerably lower than in the sub-taiga zone (+4.7°C) with similar mean annual air temperatures in these zones. A general law must be kept in mind: that the mean annual temperature is the same at different depths of the profile of a given soil. Soils of the European forest-steppe, on the other hand, have a mean annual temperature of +7° to +8° C with the usual freezing of plowed soils to a depth of 50-70 cm and complete thawing in early or mid-May. The duration of soil freezing in the European forest-steppe is 4-4.5 months, while that in the Krasnoyarsk forest-steppe is 9-10 months in plowed soil, 8 months in forests, and 7.5-8 months in the sub-taiga.

Figures 2, 3, and 4 show clearly that the differential warming with depth of chernozem, gray forest, and sod-podzolic soils in summer is due to the nature and time of thawing of the seasonally frozen layer. The later inhibits warming of the deeper layers. The thermoisopleths are less steep in chernozem than in sub-taiga soils.

The very shallow humus layer (30-40 cm) in the chernozem of the Krasnoyarsk forest-steppe is a result of the extremely short period with optimum temperatures in the deeper layers. For instance, in the layer from 80-100 cm, the period with temperatures higher than +10°C is 1-1.5 months. This, of course, lowers the degree of development of microbiological processes greatly. It is interesting to note that ground squirrels and field mice make their burrows only in a layer 30-50 cm deep. There are very few insects and earthworms in the soils; for instance, we encountered not more than 4-5 earthworms while working on 100 profiles and pits. This is due to the thermal regime of the soils.

Optimum soil temperatures occur only during the vegetative period of agricultural crops. The temperature of the soil is so low in the pre-sowing and post-harvesting periods, that weeds do not sprout. Therefore, weed control by cultivation and shallow plowing of stubble before sowing is often completely unnecessary in the Krasnoyarsk forest-steppe. The soil temperature has another peculiarity, which is determined to a great extent by the nature of the water regime. In the forest-steppe of the European USSR, annual temperature fluctuations in the soil occur to a depth of 15-20 m, while below there is a layer of constant (secular) temperatures, which increase with depth, while in the Krasnoyarsk forest-steppe constant temperatur begin from a depth of 4-5 m with +2°C to +3°C, and in the sub-taiga zone from 7-8 m with -4° to +5°C (Figs. 2, 3, 4).

The most important means of improving the thermal conditions of fields in the forest-steppe zone must be snow retention, which would also greatly improve the water regime. Owing to the presence of a snow cover in the forest, the summer thermal regime is more favorable in the forest-steppe than in a field, because the soil freezes more slowly and thaws more rapidly.

The soil warms more slowly in small plowed areas of 2-5 ha, than in larger fields of 20-50 ha in the sub-taiga zone, because of shading. This must be considered in the reclamation of new land, and plowed areas must be primarily located on southern exposures.

Soil Moisture

Concerning the amount of precipitation, the region studied is comparable to the steppe zone of the Ukraine or the Volga region. Precipitation amounts to 364-380 mm in the forest-steppe and 400-417 mm in the sub-taiga, about 45%-50% of this falls in the period from June-August. Spring is usually dry. Precipitation in the form of snow amounts to 80-90 mm in the forest-steppe and almost twice that, 150-160 mm, in the sub-taiga. The great depth of the snow (50-70 cm) and its persistence in the taiga result in a lesser depth of soil freezing as compared with the sparsely-wooded forest-steppe, where, as a rule, the wind blows the snow from open fields into ravines and woods.

During the warm periods from May-October of 1957 and 1958, the main moisture consumption occurred to a depth of 100-120 cm in leached chernozem, while below, to a depth of 2.5 m, the soil moisture content was constan and high, close to the minimum moisture capacity (MM) of soils. During May-July moisture increased to 20-30 mm in the frozen layer. Below the layer of seasonal freezing the moisture content was 22%-25% by soil volume, or 70%-80% of the MM, remaining practically motionless. During the dry growing period (June-August) of 1957, precipitation amounted to only 21 mm, while the yield of spring wheat in the given area was 17 cntr/ha. This may be explained by the fact that the roots of plants, after having exhausted the moisture in the upper layers at the beginning of the growing period, were able to penetrate into the deeper moist layers, which later provided the plants with the lacking moisture. At the moment of

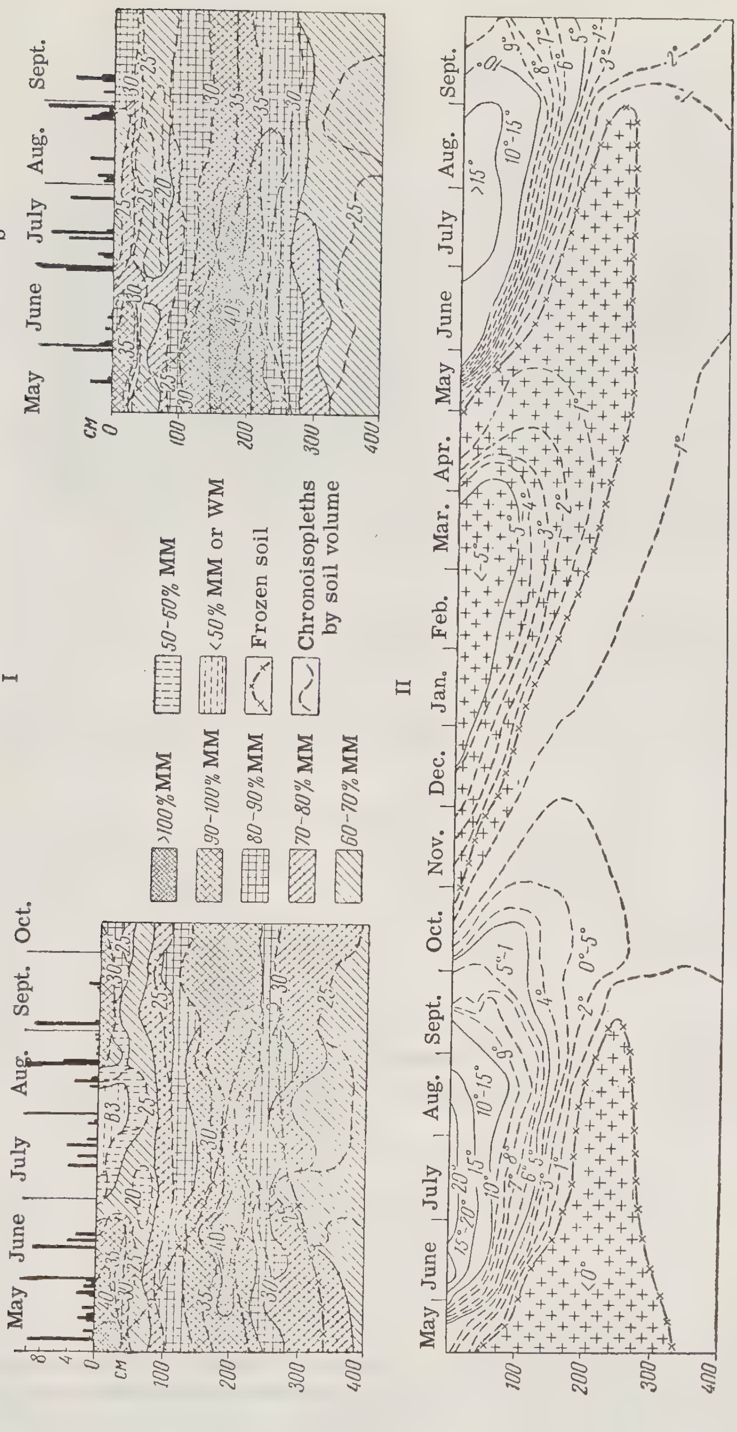

Fig. 2. - Moisture and temperature regime, Leached chernozem, profile 43.

a - barley, 1957; black fallow, 1958.
I - water regime; II - thermal regime.

wing in 1958 a dry layer remained in the ernozem at a depth of 30-70 cm (60%-70% the MM). Therefore, during the dry riod (June-July) roots were not able to netrate into moister layers. The yield of ring wheat in the plot was 6-7 cntr/ha, while in many kolkhoz fields the crop was completely lost. Dry periods in spring and summer usually occur every 2-3 years in the forest-steppe zone, but it does not greatly reflect on the yield of agricultural crops. Such a severe drought as in 1958 (which occurs 1-2 times in

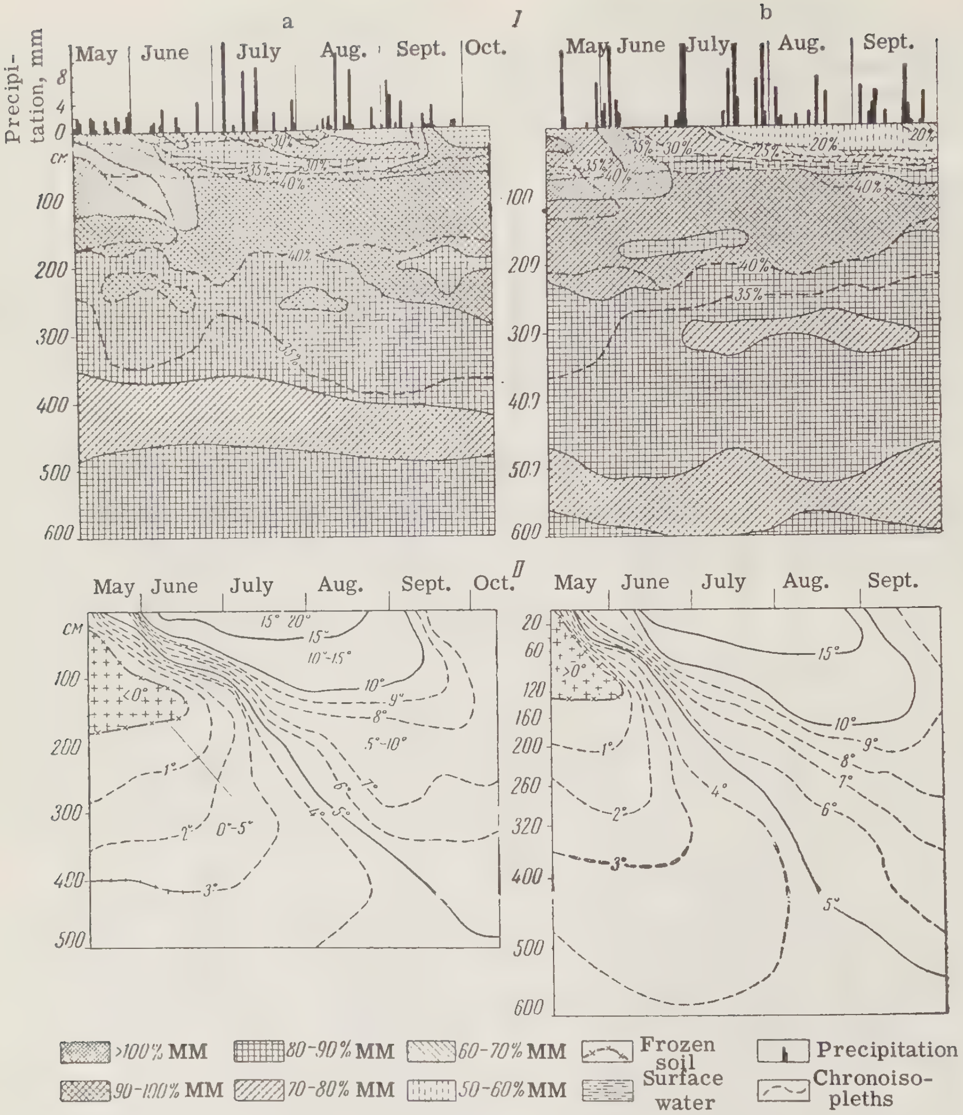

Fig. 3. - Water and temperature regime. Dark-gray forest soil, profile 41.

a - used fallow, 1957; b - wheat, 1958.
I - water regime; II - temperature regime.

20-25 yr) is attributable to droughts from 1955-1957, when precipitation was 20%-35% less than the annual normal (1957 had only 211 mm).

What we have said previously shows that even though the soil layer from a depth of 1-2.5 m in chernozem is, to a certain extent, a moisture accumulator and a moisture reservoir, its frozen condition during the growing period restricts the upward movement of moisture. As the layer thaws in summer, moisture becomes available to the roots of plants, while the moisture contained in the frozen layer remains unavailable to plants.

Dark-gray forest (Fig. 3) and sod-podzoli (Fig. 4) soils are satisfactory as far as moisture supply to plants is concerned. This may be explained not only by the more even annual precipitation distribution in the sub-taiga zon but also by the formation in individual years surface water in spring, which supplies additional moisture to plants. The complete thawing of the frozen layer by the beginning of summer creates favorable conditions for the capillary movement of water from the entire,

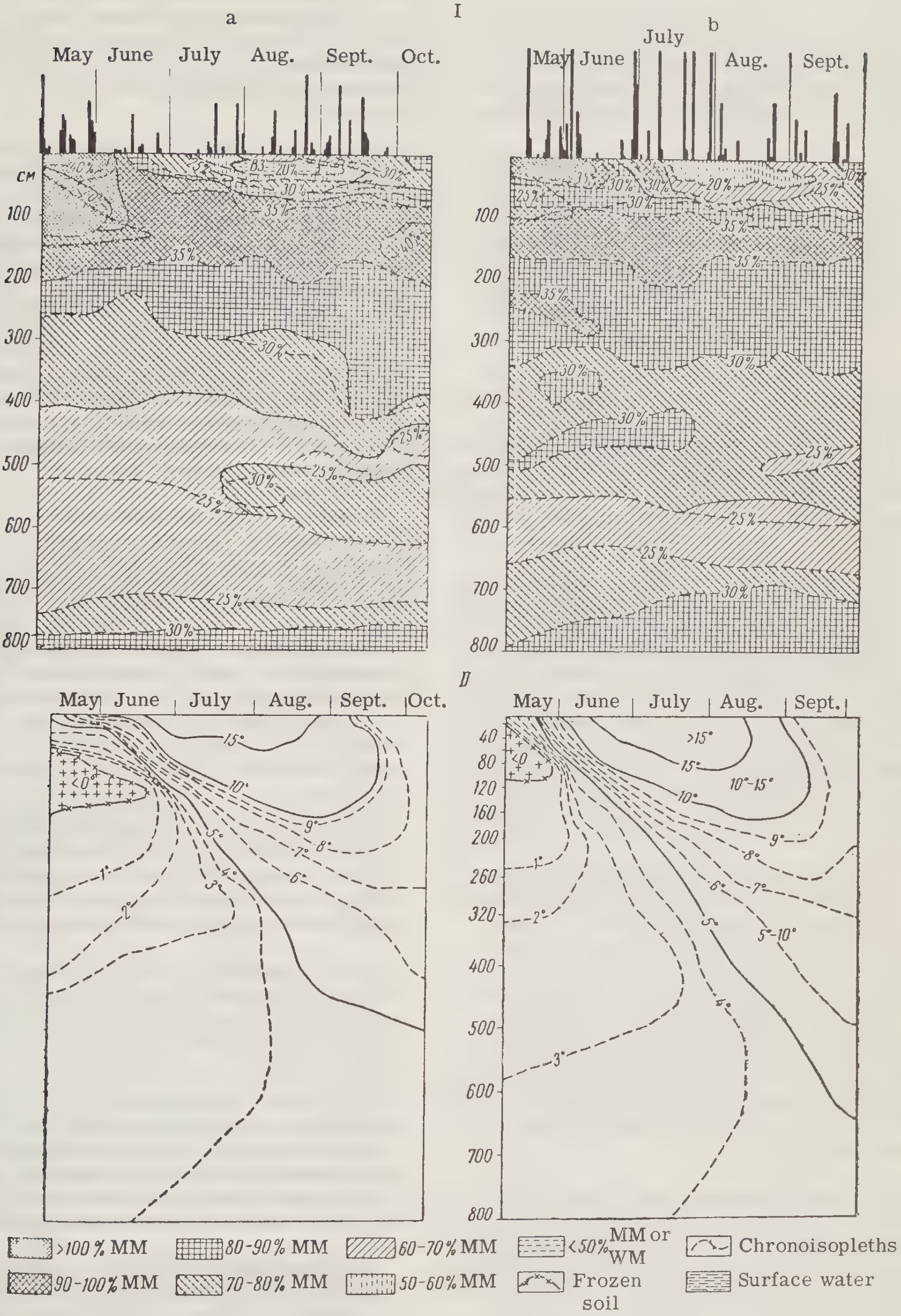

Fig. 4. - Water and temperature regime. Sod-podzolic soil, profile 46.

a - wheat, 1957; b - wheat, 1958.
I - water regime; II - temperature regime.

well-moistened soil profile.

The formation of surface water in plowed soils of the sub-taiga in 1957 may be explained by ample precipitation in October 1956 (97 mm), before the soil had frozen, and in May 1957 (93 mm), after it had already begun to thaw.

During the summer of 1957 moisture consumption occurred only in 80-100 cm layers. The spring of 1958 was comparatively dry in the sub-taiga zone, so that no surface water formed, and moisture consumption occurred in a deeper layer, 130-150 cm. The yield of spring wheat was the same on both types of soil (18-20 cntr/ha) in 1957 and 1958.

Below the upper 1-1.5 m there is a layer in these soils with a constant moisture content equal to the MM, reaching a depth of 2-2.5 m. Below this layer the moisture content decreases. Dark-gray forest soils have a moisture content of 25%-27% by soil volume or 80% of the MM at a depth of 4 m; while at a depth of 500-600 cm the moisture content increases noticeably. The moisture conditions in sod-podzolic soils are approximately the same. The moisture content decreases to 70% of the MM at a depth of 4-6 m in these soils and increases to 90%-100% of the MM at 8 m. It must be kept in mind that the texture of all soils remains uniform along the profile. The increase of the moisture content in the lowest portion of the profile is apparently related to the presence of a boundary between two materials: clay and sand and gravel. In the presence of coarse-grained material underneath, perched capillary moisture may exist in the upper layer.

Let us examine the variations in soil moisture content in the winter of 1957-1958 (Table 1). Moisture decreased by 21 mm at a depth of 200-400 cm in leached chernozem from October 3, 1957 to May 13, 1958, i. e., almost from the beginning of soil freezing (October 18-20) to the beginning of thawing (May 4-5), while moisture increased by 55 mm in the upper 2 m, 19 mm of this increased in the plow layer. Precipitation amounted to 56 mm during this period; 45 mm were in the form of snow; all of it was blown by the wind into woods and ravines.

Precipitation on dark-gray forest soil amounted to 157 mm during the period from October 6, 1957 to May 15, 1958; 142 mm were in the form of snow; the main part was discharged by surface meltwater runoff into microdepressions and ravines. There was practically no moisture movement in a layer 4 m thick, since the total consumption of 19 mm comprises only 1.3% of its total moisture content of 1497 mm. Such a value represents an allowable error under the existing methods of moisture determination. The moisture increase of 21 mm in the upper 50 cm is apparently possible only as a result of the movement of moisture from the lower layers. The dynamics of moisture in the sod-podzolic soil from October 8, 1957 to May 17, 1958, are almost identical with those in the dark-gray forest soil.

Studies by Lebedev (7), Srebryanskaya (10), Vasil'yev (1), and many others have proved th it is possible for moisture to accumulate in a frozen layer in winter; the only problem being that of the amount of moisture accumulation, and the nature of its movement as dependent o chemical and temperature gradients. The results obtained in this respect differ and are often contradictory. A. F. Lebedev explained winter accumulation of moisture in the soil by its movement in the form of vapor. However, many investigators (2, 4) believe that moisture accumulates mainly by moving in the liquid form, but they do not deny the possibility of a partial movement in vapor form.

Certain investigators point to the fact that a large amount of moisture accumulates in the upper soil layer within 2-3 winter months. For instance, Pavlovskiy (8) observed an increase of 80-202 mm and Vasil'yev (2) an increase of 34-52 mm in the sod-podzolic soil of the Moscow region. It seems that the accumulation of moving moisture must be muc greater than indicated when soils remain froz 8-10 months. But this was not the case in the winter of 1957-1958. Therefore we are inclined to think that the duration of freezing is not the main factor governing moisture accum lation in the frozen layer. Apparently the temperature gradient manifests itself in this respect in a very complicated and unusual manner. An important role is probably playe by texture, the degree of wettness, depth of ground water and a number of other factors.

The constantly high moisture content at a depth of 1-3 m in all the soils studied and the considerably lower moisture content at a dept of 4-6 m may be explained only by the constan (secular) moisture movement toward the laye of seasonal freezing, even though its values are small in the course of one year. Using the formula of Deryagin (4) we have calculate the possible moisture accumulation in the frozen layer as a result of the moisture movement in vapor form in the course of 9 months. The value obtained for chernozem was 22 mm

It is known that non-leaching steppe soils of the European USSR usually become wetted to a depth of 1.5-2 m, while a decrease in moisture takes place below, to the so-called dry "dead" layer. The soils of the forest zon of the European USSR have a water regime of the leached type, whereby the moisture conte below 2.5-3 m is always high, near the MM (The moisture profile of soils in the Krasno-

Table 1

Dynamics of soil moisture contents in winter, mm

Horizon, cm	Leached chernozem, profile 43			Dark-gray forest soil, profile 41			Sod-podzolic soil, profile 46		
	Oct. 3, 1957	May 13, 1958	Increase	Oct. 6, 1957	May 15, 1958	Increase	Oct. 8, 1957	May 17, 1958	Increase
0—20	60	79	+19	61	68	+7	84	79	—5
20—50	75	79	+4	86	100	+14	74	90	+16
50—100	110	119	+9	216	201	—15	160	158	—2
100—200	322	355	+33	406	404	—2	367	340	—27
200—300	310	308	—2	383	366	—17	340	334	—6
300—400	275	256	—19	364	358	—6	312	313	+1
0—400	1152	1196	+44	1416	1497	—19	1337	1314	—23

Note: On chernozem the wind blows all the snow from the soil surface. Meltwater runs off on the surface of frozen soil in dark-gray forest and sod-podzolic soils, i. e., soil thawing begins 5-10 days after the snow has disappeared.

rsk forest-steppe and sub-taiga, however, quite different, as may be seen from Figs. 3, and 4. There, a type of constantly sus- nded moisture is observed in the center of il profiles while below that the moisture con- nt decreases. For instance, three well- fined moisture zones are distinguished in layer 4 m thick in leached chernozem (Fig. .

The first zone embraces a layer to a depth nearly 100-120 cm; it is characterized by arp seasonal moisture fluctuations. In y years, the moisture content reaches the M only in the upper 40-50 cm, where dis- cation proceeds in June-August to the WM, ile the moisture content in the lower part the zone remains within 60%-70% of the M throughout the year. The moisture con- nt of this zone in the spring equals the MM normal and wet years, and the zone merges th the second zone.

The second zone (of late thawing) reaches a pth of about 250-280 cm, embracing the soil yers which thaw last. Its moisture content always high (near the MM) throughout the ar. This zone serves as a moisture reser- ir for plants in normally dry years.

The third zone (below the freezing layer) aches the gravel horizon (about 280-400). It has a much lower moisture content, out 60%-80% of the MM. Assuming con- tionally that atmospheric precipitation could netrate into this zone, this could only occur September-October during heavy autumn ecipitation when the freezing layer has awed completely.

The soils of the sub-taiga zone have fundamentally the same characteristics of zonal wetting throughout the soil profile as leached chernozem, even though it is expressed in a lesser degree. Two years of study have indicated that, under forest-steppe conditions, level areas have a non-leaching type of water regime, which must be differentiated from the analogous type of water regime in the European USSR as a prolonged-seasonal freezing type, probably a sub-type. The water regime of sub-taiga soils is of the non-periodic leaching type. Taking into account the period of observation, our conclusions as to the types of water regime must be considered as preliminary.

Conclusions

1. Leached chernozem of the Krasnoyarsk forest-steppe, even though it does not have a blocky to granular structure, has good physical properties, which are determined by its good microstructure.

2. The unsatisfactory physical properties of sod-podzolic soils are determined by the absence in them of a micro- and macrostructure. Four sequences of grass rotations without the addition of lime did not improve their structure.

3. The water and thermal regime of soils of the Krasnoyarsk forest-steppe and sub-taiga differs greatly from the regime of similar soils in the European USSR. Low temperatures in winter cause deep and prolonged soil freezing, to a depth of 2.5-3.5 m for a period of 9-10

months in the forest-steppe, and to 1-1.5 m for a period of 7-8 months in the sub-taiga zone. Such a sharp difference is attributable to the fact that the snow cover is blown away by the wind from open fields in the forest-steppe.

4. The period of optimum soil temperatures (>+10°C) lasts only from 3-3.5 months because of prolonged freezing, especially in chernozem. This leads to a weak development of microbiological processes in the soil, and also reduces to the minimum the time for agricultural melioration in the pre-sowing and post-harvesting periods, in particular weed control.

The most important means for improving the water and thermal regime of soils in the open forest-steppe is snow retention, and in the sub-taiga zone, the proper arrangement of cultivated plots (of not less than 30-50 ha) on southern exposures.

5. The soils studied have a constant high moisture content (near or equal to the MM) from a depth of 100-150 to 200-250 cm and a decreasing moisture content at depths of 4-6 m. Such moisture conditions are apparently due to the constant movement of moisture in the capillary, film, and vapor form as a result of the prolonged freezing of these soils.

6. The movement and accumulation of soil moisture were insignificant in the winter of 1957-1958, and occurred primarily in the freezing layer.

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OLONETZES OF THE MIL'SK ALLUVIAL PLAIN KURA-ARAKS LOWLANDS)

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The Mil'sk plain is the part of the Kura- raks lowland within the Azerbaydzhan SSR. lies on the right bank of the Kura River, in ie triangle bounded by the Kura and Araks ivers and the foothills of the Eastern Karabakh ange of the Lesser Caucasus, in the semi- esert zone of the dry subtropical belt. The ifference in absolute elevation within the Iil'sk plain exceeds 150 m (from +140 m on ie southwest in the piedmont section to -13 m here the Araks enters the Kura). The plane zero elevation divides the territory almost half into a diluvial-proluvial sloping pied- ıont plain (above 0 m) and an alluvial plain elow 0 m).

This distribution of soils in the area is shown Figure 1. On the soil map compiled by V. M. ridland, V. R. Volobuyev, and others, solon- tzes are not separated within the Mil'sk plain. t the same time we think it is possible to esignate the soils considered below as solon- tzes, although they also possess certain pecific characteristics. As we know, the haracteristic features of "classical" solonetzes re: the presence of a compact solonized B_1 orizon, distinguished by an unusual structure olumnar), prismatic, cloddy, a high content exchangeable sodium (more than 25%-30% of e total exchangeable cations), weak saliniza- on, poor water permeability, pronounced velling, and high alkalinity. The salt accumu- tion in "classical" solonetzes is ordinarily ob- rved in the subsolonetz horizons, sometimes considerable depth. In addition to the "classi- l" solonetzes, we often encounter types in hich a high accumulation of salts is noted in e compact horizon. These so-called solon- ak-like solonetzes are characteristic of the midesert zone. Now such solonetzes develop the Mil'sk alluvial plain (inside contours 6 d 8 on the soil map). Their distinguishing fea- res, already noted by Tyuremnov (13), are: rong salinization of the soil profile, calcare- s from the surface, the absence of calcareous uvial horizons, weak differentiation of the il profile, indications of excessive moisture the lower horizons (at a depth of about 3-4 m).

According to the existing classification (2, 8) the solonetzes found in the Mil'sk alluvial plain may be classed as meadow and meadow-steppe solonchaks and solonchak-like, crusty and medium-columnar soils, with a sulfate-chloride type of salinization. The designation "meadow-steppe" with reference to solonetzes of the semidesert zone is rather conditional. But it would also be provisional to call them "meadow-desert." Therefore we think they can be called meadow-steppe soils, understanding the process of "steppization," following Kovda (7), as the process of development of solonetzes under the influence of vegetation in the course of their transformation to zonal soils. Opinions on the zonal soils of the Kura-Araks lowland up to this time have not been in complete agreement. The majority of investigators of the Azerbaydzhan SSR consider sierozem soils to be the zonal group (Fig. 1). According to the opinion of Rozanov (12), gray-brown soils are zonal soils. We accept the view of Rozanov.

Solonetzes were first identified in the Mil'sk lowland by Zakharov (6); then they were described by Tyuremnov (13) and Nozhin (9).[1] However, their analytic features were very incomplete. The works mentioned contain only the analyses of concentrated water extracts containing CO_2 and humus. Our knowledge of the solonetzes of the Mil'sk plain is limited to this. The present paper is intended to provide a more detailed description of them. We selected four profiles which we think can be considered as successive stages in the evolution of solonetzes toward the steppe condition. The location of the profiles is diagrammed in Figure 2. All four profiles were located on the gently rolling alluvial plain, with individual poorly pronounced elevations and saucer-shaped depressions. The parent materials here are

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[1] The development of solonetzes and solonetz-like soils in other regions of the Kura-Araks lowland also has been discussed in a number of the works of Azerbaydzhan investigators (3, 4, 11, etc.).

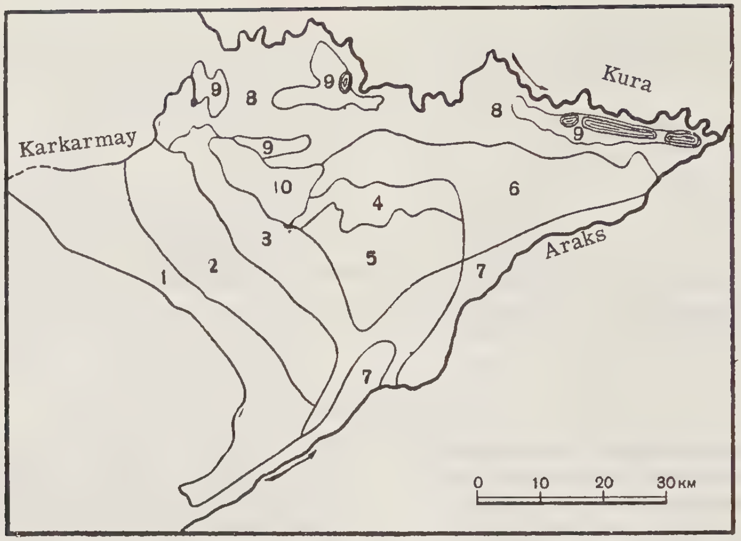

Fig. 1. - Soil map of the Mil'sk plain (from the map of V. M. Fridland V. R. Volobuyev, and others).

1 - Brown desert-steppe and chestnut soils of the eastern Transcaucasus (light gray-chestnut) medium and coarse-clay loams, on surface deposits; 2 - irrigated sierozems, clays and fine clay loams, on surface deposits; 3 - meadow-sierozems, clays and fine clay loams, on surface deposits; 4 - meadow-sierozems, complex with solonchak-like meadow sierozems, medium and coarse clay loams, on alluvial deposits; 5 - meadow-sierozems, solonchak-like, complex with poorly developed sierozems, medium and coarse clay loams, on alluvial deposits; 6 - meadow-sierozems, solonchak-like, complex with solonchak-like meadow-sierozems; clays and fine clay loams on alluvial deposits; 7 - meadow, clays and fine clay loam on alluvial deposits; 8 - meadow, complex with meadow-bog, meadow solonchak-like, and solonchak, clays and fine clay loams, on alluvial deposits; 9 - meadow-bog; 10 - solonchaks.

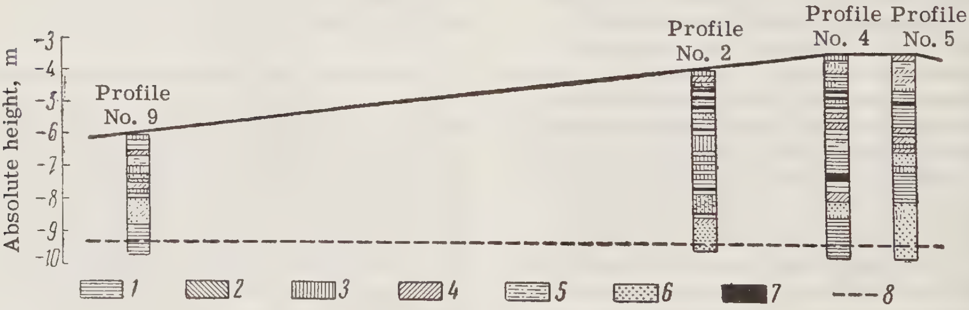

Fig. 2. - Distribution of solonetz profiles with indication of their lithology.

1 - clay; 2 - fine clay loam; 3 - medium clay loam; 4 - coarse clay loam; 5 - sandy loam; 6 - sand; 7 - buried soil; 8 - water table.

stratified, predominantly clay loam and clay alluvial deposits of the Araks. The ground water of all the solonetzes described comprises a single ground-water horizon characterized by strong mineralization. The profile sites differ one from the other in their situation as regards microrelief and vegetation.

Profile 9. Described on September 7, 1952. Meadow type, crusty, solonchak-like solonetz. The vegetation consists chiefly of herbaceous ephemerals. Cutleaf peppergrass, Lipidium perfoliatum [3][2] and mortuk wheat Eremopyrum triticeum [3] predominate; there is the

Footnote No. 2 on next page.

bulbous meadow grass Poa bulbosa (1-2); the little-leaf Dondia Suaeda microphylla is met occasionally (1); isolated instances of timothy Phleum sp., Japanese brome-grass Bromus japonicus, and the sea lavender Statice spicata are found. The area of vegetative cover on the soil is 80%-90%. The soil surface is fissured.

B_1^- 0-12 cm Brown, dry, clay loam, columnar to cloddy. In the upper part, 0-5 cm, less compact; clods separate into angular-blocky units. In the lower part, 5-12 cm, very compact.

$B_1^=$ 12-21 cm Brown, slightly green, clay loam, cloddy, compact, separated with difficulty from the upper horizon.

B_2/C 21-60 cm Reddish-brown green Araks clay, ridged-blocky structure, with shell-like fracturing, with large amount of salts, humified in the upper part; at a depth of 43-48 cm bluish spots of gleyed clay are encountered.

C 60-200 cm Stratified layers of Araks alluvium of various textures: clay loam-clay-sandy loam,[3] with rust-colored patches and accumulations of salts. Moisture gradually increases downward.

C 200-280 cm Fined-grained wet sand, with a seam of coarse clay loam at a depth of 230-235 cm.

C 280-370 cm Red-brown Araks clay, moist, wet below, sticky, with rust-colored and dark-brown patches, with inclusions of accumulated salts.

The water table is at 323 cm. Effervescence from HCl is observed from the surface. Poorly defined diffused calcareous patches are encountered from 12-100 cm.

In Profile No. 9 the columnar to cloddy horizon extends from the surface itself and is 21 cm thick; it is characterized by a high degree of compaction; the cloddy structure is difficult to break down into smaller units. Intense coloration of suspensions by phenolphthalein is found in the columnar horizon (from 5-20 cm), which is characterized by a high alkalinity (to 0.09%-0.10% HCO_3^- and 0.003%-0.013% CO_3^{--}), a high pH value (8.9-9.0), a high content of water-soluble humus (about 0.07%), and the absence of gypsum (Tables 1, 2, and 3). The adsorption capacity is 25-30 meq per 100g of soil. The degree of salinization of this horizon is also high — from 0.4% to 1.1%. This is related to the strongly mineralized ground water (about 37 g/l), which lies at a depth of three meters. Salinization and desalinization processes alternate in the soil profile. This is shown by the accumulation of gypsum in the layers located immediately above the water table and below the solonetzic horizon at the edge of the capillary fringe (where the gypsum concentration amounts to 7%-8%). The q_1:q ratio, according to Polynova (10), is 9-12 (Table 4) in the solonetzic horizon. This indicates seasonal attraction of chlorides into the solonetzic horizon at the time when the samples were taken (September, 1952).

Profile No. 2. Described on July 28, 1952. Solonetz meadow-steppe, crusty, solonchak-like. Vegetation is predominantly herbaceous ephemerals. Bulbous meadow grass predominates (3-4);[2] much cutleaf peppergrass, Lepidium perfoliatum (2-3); wheat and eastern mortuk, Eremopyrum triticeum and E. orientale, are found (1), as are Japanese brome-grass, Bromus japonicus (1-2), isolated instances of timothy, Phleum sp., and the saltwort Salsola dendroides. The area of the soil covered with vegetation is 100%. The surface of the soil is fissured. The width of the fissures is 0.5-2 cm; their depth, 7-10-12 cm.

A/B_1 0-16 cm Grayish-brown, dry, clay loam, columnar to cloddy. From the surface through the 0-1 cm layer lamination appears locally. The upper part of this horizon, from 0-7 cm (in places to 12), is very compact; the lower part is less dense; the columns divide into small clods and sharp blocks.

B_2 16-25 cm Brown, slightly immature, coarse clay loam, with lighter silt-like lenses. Structureless, not compacted. Occasionally thin veins of salts are found.

B_2 25-35 cm Brown, immature, coarse clay loam, friable, structureless with large numbers of fine salt veins.

B_2 35-50 cm Brown, locally with reddish tinge, immature, clay loam to clay-like with light grayish-yellow sand lenses, friable blocky structure. Very high in salts.

B_2 50-133 cm Red-brown, structured, with clear shell-like lamination, Araks clay. In the upper portion slightly moist, not compacted; in the lower portion moist, compacted. At depths of 58-62, 85-90, and 100-113 cm dark carbonaceous layers of buried soils are found.

B_2 133-350 cm Stratified layers of Araks alluvium — clay and clay loams, with

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[2] Figures in brackets after plant names show the abundance of the particular species according to the 5-point scale of A.A. Grossgeym (the maximum abundance is designated as 5).

[3] Stratified layers of different textures may be seen from the lithological columns given in the profile distribution diagram (Fig. 2).

Table 1

Data from the analysis of the water extracts, gypsum, and CO_2 from soil samples for Profile No. 9

Depth, cm	Mois-ture	Water extract										$SO_4^=$ in HCl	$CaSO_4 x 2H_2O$ water-sol. portion accounted for	CO_2
		Solid residue	Alkalinity		Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+ by differ-ence	Na^+	K^+			
			$CO_3^=$	Total in HCO_3^-						Determined by the flame photometry method[a]				
	In percents for absolutely dry soil													
0—5	4.9	0.468	0.003	0.090	0.176	0.008	None	0.001	0.150	0.141	0.003	0.039	0.055	3.08
5—12	5.7	0.865	0.008	0.101	0.405	0.026	0.003	Trace	0.309	0.307	0.002	0.082	0.100	3.60
12—21	6.0	1.105	0.013	0.090	0.454	0.128	0.002	0.001	0.384	0.371	0.002	0.175	0.084	3.60
21—26	6.2	3.012	None	0.034	0.578	1.284	0.212	0.042	0.680	0.695	0.006	2.787	3.551	3.60
26—48	6.8	4.055	"	0.027	1.054	1.430	0.297	0.083	0.880	0.856	0.007	5.150	7.900	4.22
48—60	5.9	4.644	"	0.022	1.420	1.462	0.313	0.104	1.072	0.954	0.007	4.710	7.128	5.02
60—75	3.2	3.640	"	0.026	1.630	0.545	0.136	0.085	1.008	0.930	0.006	0.657	0.748	5.27
75—90	5.2	4.181	"	0.022	1.440	1.175	0.226	0.089	1.081	0.996	0.007	2.096	2.590	5.18
90—100	2.9	2.384	"	0.026	0.902	0.528	0.078	0.054	0.654	0.644	0.006	0.824	0.831	2.46
100—150	3.0	2.393	"	0.029	0.902	0.521	0.082	0.043	0.668	0.669	0.006	0.722	0.675	6.15
150—200	3.7	2.782	Trace	0.024	0.986	0.709	0.106	0.055	0.761	0.728	0.007	1.252	1.394	5.80
200—250	2.5	1.881	None	0.025	0.710	0.415	0.038	0.031	0.565	0.510	0.005	0.530	0.335	4.84
250—280	2.6	1.795	"	0.030	0.695	0.364	0.030	0.027	0.549	0.479	0.005	0.435	0.217	4.40
280—300	5.0	2.643	Trace	0.032	0.460	1.188	0.176	0.048	0.609	0.625	0.006	1.537	1.249	5.45
300—350	5.1	2.448	None	0.026	0.450	1.061	0.061	0.048	0.533	0.577	0.008	2.064	2.449	5.18
350—370	5.4	2.440	"	0.026	0.660	0.870	0.097	0.045	0.656	0.593	0.008	1.791	2.032	4.49
Ground water from a depth of 323 cm, in g/l	—	36.6	—	0.4	14.9	8.2	0.8	1.4	10.2	—	—	—	—	—

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[a] Na and K were determined by the flame photometry method in all cases (Tables 1, 5, 6, 7) by N. P. Ivanova; ground-water analyses were done by I. P. Sheina.

Table 2

Content of humus and exchangeable cations in the solonetzes

Profile No.	Depth, cm	Salt content in water extract, %	Humus content: Total	Humus content: Water-soluble	Humus content: Water-soluble in % total	Adsorption capacity	Exchangeable Na^+	Exchangeable K^+	Exchangeable Na^+	Exchangeable K^+
			In % soil wt.	In % soil wt.		In mew per 100 g soil	In mew per 100 g soil	In mew per 100 g soil	In % adsorption capacity	In % adsorption capacity
9	0—5	0.468	1.85	0.068	3.7	24.8	9.09	1.15	37[a]	5
	5—12	0.865	1.40	0.068	4.9	30.2	14.00	0.82	46[a]	3
	12—21	1.105	1.29	0.069	5.4	Not det'd.				
	21—26	3.012	1.06			Not det'd.				
	26—48	4.055	0.76			" "				
	48—60	4.644	0.60			" "				
2	0—10	0.575	1.84	0.061	3.3	19.6	5.35	1.54	27[a]	8
	10—16	0.660	1.55	0.058	3.7	22.3	7.92	0.97	36[a]	4
	16—25	1.800	1.18	0.057	4.8					
	25—35	2.537	0.89			Not det'd.				
	35—50	3.270	0.74			" "				
4	0—7	0.137	2.08	0.041	2.0	12.3	1.09	0.72	9	6
	7—13	0.171	1.17	0.050	4.3	13.5	2.91	0.03	22	—
	13—20	0.202	1.05	0.052	5.0	18.4	4.26	None	23	—
	20—40	0.338	0.83	0.055	6.6	20.5	7.43	0.13	36	1
	40—60	0.965	0.65	0.057	8.8	Not det'd.				
5	0—12	0.144	1.44	0.036	2.5	11.6	0.26	1.15	2	10
	12—22	0.150	1.00	0.033	3.3	19.7	1.18	1.31	6	7
	22—35	0.190	0.64	0.046	7.2	13.3	5.18	0.90	39	7
	35—50	0.232	0.40	0.036	9.0	14.2	5.13	0.46	36	3
	50—65	0.838	0.40	0.029	7.3	13.2	2.63	0.23	20[a]	2

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[a] Data for the determination of exchangeable cations unreliable because of high salt content.

Adsorption capacity determined by R. N. Yeremina; exchangeable Na^+ and K^+ were determined by N. P. Ivanova by the flame photometry method (samples for analysis prepared by R. N. Yeremina by the method of K. K. Gedroyts).

Table 3

Results of pH determinations for solonchak-like solonetzes

Profile No. 9: Depth, cm	Profile No. 9: pH Water	Profile No. 9: pH Salt	Profile No. 2: Depth, cm	Profile No. 2: pH Water	Profile No. 2: pH Salt	Profile No. 4: Depth, cm	Profile No. 4: pH Water	Profile No. 4: pH Salt	Profile No. 5: Depth, cm	Profile No. 5: pH Water	Profile No. 5: pH Salt
0—5	8.9	7.9	0—10	8.7	8.0	0—7	8.4	7.7	0—12	8.2	7.7
5—12	9.0	7.8	10—16	9.2	8.1	7—13	8.4	7.6	12—22	8.8	7.9
12—21	9.0	8.1	16—25	8.3	7.8	13—20	8.7	7.7	22—35	9.5	8.0
21—26	8.2	7.9	25—35	8.2	7.7	20—40	9.2	7.8	35—50	9.3	8.0
—	—	—	—	—	—	40—60	8.8	7.9	50—65	8.4	7.8
—	—	—	—	—	—	60—80	8.3	Not det'd.	65—95	8.7	8.1

alt pockets. Moisture increases downward.

B_2 350-470 cm Unevenly colored, rown, sometimes with reddish tinge, with ighter patches; non-uniform texture — clay o clay loam with sandy lenses. Moist, with ust-colored and blue gleyed patches. Dark ayers are found at depths of 360 and 440 cm.

B_2 470-550 Dark gray water-permeable sand, aquifer. Water table at 530 cm depth. Effervescence from HCl observed at the surface. Poorly defined diffuse patches of carbonates occur from 16 to 200 cm.

In Profile No. 2 the columnar to cloddy B_1 horizon extends from the surface, but in places

Table 4

q_1:q ratio after B. B. Polynova

Profile No. 9		Profile No. 2		Profile No. 4		Profile No. 5	
Depth, cm	q_1:q ratio (after Polynova)	Depth, cm	q_1:q ratio (after Polynova)	Depth, cm	q_1:q ratio (after Polynova)	Depth, cm	q_1:q ratio (after Polynova)
0—5	12.1	0—10	2.9	0—7	0.5	0—12	0.3
5—12	8.8	10—16	1.5	7—13	2.0	12—22	0.4
12—21	2.0	16—25	0.4	13—20	3.2	22—35	1.1
21—26	0.2	25—35	0.5	20—40	2.4	35—50	0.1
26—48	0.4	35—50	0.8	40—60	1.0	50—65	0.1
48—60	0.5	50—70	1.2	60—80	1.0	65—95	0.3
60—75	1.7	70—85	1.8	80—100	1.0	95—130	0.6
75—90	0.7	85—100	1.3	100—120	1.0	130—160	0.5
90—100	1.0	100—120	1.2	120—140	0.5	160—200	0.4
100—150	1.0	120—133	0.7	140—170	0.5	200—250	0.6
150—200	0.8	133—150	1.9	170—200	0.4	250—300	0.9
200—250	1.0	150—170	1.1	200—250	0.3	300—340	0.9
250—280	1.1	170—200	0.9	250—300	0.4	340—400	0.7
280—300	0.2	200—250	0.7	300—360	0.3	400—450	0.6
300—350	0.2	250—300	0.3	360—400	0.3	450—500	0.8
350—370	0.4	300—350	0.7	400—450	0.4	500—580	1.0
—	—	350—400	0.7	450—500	0.6	—	—
—	—	400—450	0.7	500—550	0.5	—	—
—	—	450—500	0.8	550—600	0.3	—	—
—	—	500—550	0.6	600—620	0.3	—	—

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q_1 is the Cl:SO_4 ratio in the soil horizons; q is the Cl:SO_4 ratio in the ground water.

a laminar structure is observed in the 0-1 cm layer, which indicates that an A horizon is beginning to form. The B_1 horizon is 16 cm thick; the columns separate into smaller structural units more easily than in Profile No. 9. Intense phenolphthalein coloring is observed not only in the columnar horizon but also considerably deeper, to 50 cm. In the columnar horizon an increased HCO_3^- content is observed, to 0.08%-0.10%, and the content of water-soluble humus is about 0.06%. The pH is 8.7-9.2 (Tables 2, 3, and 5). The salt content here is also large, about 0.6%. The adsorption capacity amounts to 20-22 meq per 100 g of soil. The gypsum content below the columnar horizon to depths of 50-70 cm does not exceed 1.6% $CaSO_4 \times 2H_2O$ (Table 5). The strong salinization of the soil profile is associated with the effect of the ground water, capillary solutions of which periodically reach the surface (Table 4).

Profile No. 4. Described on August 2, 1952. Solonetz, meadow-steppe (in process of becoming a steppe soil), crusty, solonchak-like. The vegetation is predominantly herbaceous ephemerals. Japanese brome-grass, Bromus japonicus (4-3);[2] there is much cutleaf peppergrass, Lepidium perfoliatum (3); there is red zerna, Zerna rubens (1-2) and bulbous meadow grass, Poa bulbosa (1-2); individual instances of Meyyer's wormwood, Artemisia meyeriana. The area of soil covered by vegetation is 100%.

A_1 0-1 cm Light gray, dry, clay loam, friable, platy.

A/B_1 1-20 cm Gray-brown, grayish brown below, dry, clay loam, columnar to cloddy. In the upper portion, 1-7 cm, columnar, fissured, compact, divides with difficulty into cloddy units. In the middle portion, 7-13 cm, columnar, not compacted, easily divides into coarse-blocky and cloddy units. In the lower portion, 13-20 cm, cloddy, compact; clods divide into coarse-blocky units.

B_2 20-40 cm Light brown with dark streaks of humus, with rust-colored and light-colored patches, immature, clay loam to sandy loam, friable. Salts occasionally found in the form of spots.

B_2 40-60 cm Brown, immature, medium clay loam, with layer of light-colored, coarse, silty clay loam and lenses of reddish brown clay.

B_2 60-420 cm Reddish brown, moist, structured Araks clay, friable above (60-100

Table 5

Data from the analysis of the water extracts, gypsum, and CO_2 from soil samples for Profile No. 2

Depth, cm	Moisture		Water extract									$SO_4^=$ in HCl	$CaSO_4 x 2H_2O$ water-sol. portion accounted for	CO_2
		Solid residue	Alkalinity		Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+ by difference	Na^+	K^+			
			$CO_3^=$	Total in HCO_3^-						Determined by the flame photometry method[a]				
	In percents for absolutely dry soil													
0—10	3.4	0.575	None	0.078	0.212	0.066	0.010	0.002	0,184	0.177	0.008	0.104	0.068	5.45
10—16	3.8	0.660	"	0.099	0.197	0.119	0.012	0.001	0,206	0.198	0.004	0.168	0.088	6.24
16—25	4.1	1.800	"	0.040	0.334	0.810	0.131	0.038	0,397	0.417	0.007	1.013	0.868	6.33
25—35	4.3	2.537	"	0.034	0.581	1.028	0.207	0.066	0,521	0.530	0.006	1.037	1.176	6.15
35—50	5.0	3.270	"	0.034	0.959	1.087	0.248	0.104	0,675	0.677	0.006	1.271	1.607	5.71
50—70	4.7	2.916	"	0.032	1.031	0.770	0.158	0.102	0,675	0.677	0.006	1.277	1.357	4.83
70—85	5.4	2.963	"	0.034	1.224	0.620	0.107	0.100	0,792	0.822	0.006	1,036	1.158	4.92
85—100	5.8	3.178	"	0.032	1.164	0.789	0.126	0.114	0,782	0.848	0.006	1.364	1.525	5.01
100—120	5.3	3.150	"	0.031	1.107	0.820	0.118	0.108	0,781	0.822	0.006	1.371	1.448	4.92
120—133	5.9	3.982	"	0.031	1.114	1.381	0.257	0,127	0,862	0.880	0.007	2,911	3.800	4.40
133—150	3.0	4.140	"	0.025	1.730	0.820	0.135	0,155	1,073	1.071	0.006	1,136	1.112	5.18
150—170	4.5	3.045	"	0.035	1.047	0.883	0.087	0.086	0,850	0.840	0.005	1.418	1.283	4.31
170—200	4.5	2.430	"	0.035	0.753	0.772	0.068	0,063	0,674	0.672	0.005	1.031	0.820	4.13
200—250	3.3	2.232	"	0.028	0.618	0.792	0.091	0,059	0,573	0.608	0,004	1.444	1.516	6.60
250—300	2.6	2.483	"	0.027	0.489	1.213	0.226	0.085	0,487	0.515	0,004	2.333	2.902	6.24
300—350	2.2	1.702	"	0.034	0.485	0.585	0.028	0,023	0,531	0.510	0,003	0.688	0.258	6.42
350—400	2.9	1.611	"	0.041	0.435	0.574	0.019	0,015	0,512	0.490	0.003	0.706	0.297	6.42
400—450	2.5	1.025	"	0.057	0.283	0.338	0.006	0,018	0,326	0.335	0,002	0.378	0.040	5.89
450—500	1.9	0.725	"	0.057	0.205	0.226	0.006	0,013	0,230	0.241	0.002	0.218	0.015	5.10
500—550	0.8	0.463	"	0.047	0.108	0.162	0.006	0.016	0,127	0.142	0,002	0.176	0.014	3.00
Ground water from a depth of 530 cm, in g/1	—	25.5	—	1.1	8.2	7.6	0.4	1.1	6.8	—	—	—	—	—

cm), compacted below. Occasionally inclusions of coarser texture are encountered — of medium clay loam at depths of 80-100 cm and 140-170 cm, of coarse clay loam at a depth of 137 cm, and a layer of sandy loam at 270-280 cm. In places dark carbonaceous layers of buried soils are found (at depths of 102-106, 128-133, 140-170, and 360-420 cm). In places along the profile small rust-colored bands and spots are found — at depths of 80-100 and 170-200 cm. From 320 to 360 cm there is clay of a dark blue color, intensely gleyed.

B$_2$ 420-450 cm Light brown, moist, friable, sandy, coarse clay loam.

B$_2$ 450-480 cm Greenish gray, very moist sand.

B$_2$ 480-500 cm Brown, moist clay loam, with lenses of reddish-brown clay.

B$_2$ 500-620 cm Red-brown with dove-colored patches of Araks clay, compact, very moist, damp and wet below, gleyed in places (large patches).

Water table at 590 cm. Effervescence from HCl observed from the surface. There are poorly defined diffuse spots of carbonates from 20 to 300 cm.

Profile No. 4 is characterized by the presence of an A horizon, even though very thin (0-1 cm). The columnar cloddy horizon is 19 cm thick; its compactness is not uniform — in the middle portion (7-13 cm) it is less compacted and the columns divide easily into smaller units. Intense coloration with phenolphthalin is observed at a depth of 16-50 cm, chiefly below the columnar horizon. Less intense coloration is observed to 150 cm. This solonetz is distinguished by the leaching of the upper horizons of the soil profile to a depth of more than 40 cm, by the absence of gypsum within the upper 60 cm (Table 6), and a decreased content of water-soluble humus (0.05%). The columnar horizon is characterized by an increased content of exchangeable sodium (up to 23% of the adsorption capacity) and an increased alkalinity (to 0.10% HCO_3^-); the pH is 8.4-8.7. But the maximum content of exchangeable sodium, equal to 36% of the adsorption capacity, the maximum alkalinity, amounting to 0.12% HCO_3^-, and the highest pH (9.2) are observed, not in the columnar horizon, but below it (at a depth of 20-40 cm). This may indicate the beginning of desolonetzation of the soil, which is accompanied by a displacement of Na^+ from the absorbing complex, by the formation of sodium-carbonate, and transfering it to the lower depth of the profile. The process of desolonetzation is connected with the influence of the grass and wormwood, which enrich the upper layers of the soil with the salts of calcium and potassium. The content of Ca^{++} in the 0-7 cm layer equals about 18 eq %; that of K^+, about 9 eq %. In this soil as well as in that mentioned previously there is an alternation of salinization and desalinization, but the latter predominates. This can be deduced from the nature of the q_1:q ratio, the value of which across the profile is mainly below unity (Table 4). A seasonal attraction of chlorides is observed in the layers from 7-40 cm, where the q_1:q ratio equals 2-3. Chlorides are deficient in the upper layer from 0-7 cm (q_1:q = 0.5); this layer is subject to intense desalinization and desolonetzation in the process of steppe-soil development.

Profile No. 5. Described on August 2, 1952. Meadow-steppe solonetz (steppe-affected), solonchak-like. The vegetation is predominantly Meyyer's polyn, Artemisia meyeriana (3),[2] and bulbous meadow grass, Poa bulbosa (3), with considerable admisture of cutleaf peppergrass, Lepidium perfoliatum (2-3); there is the Japanese brome-grass, Bromus japonicus (1-2); red zerna, Zerna rubens (1-2), malcolmia, Malcomia contortuplicata (1), zhabnitsa, Filago spathulata (1), malvalthea, Malvalthea transcaucasica (1), and the sand wormwood, Artemisia arenaria (1), are also present. Surface coverage of the soil by vegetation is 80%-90%. The soil surface is 50% sodded.

A 0-10(15) cm Gray, dry, friable, coarse clay loam. It is characterized by unstable columns, which separate easily into platy, blocky, and fine cloddy units. In places the upper layer, 2-3 cm thick, has a foliated structure.

B' 10(15)-20(22) cm Gray-brown, dry, coarse clay loam to sandy loam, non-compacted columnar. The columns divide easily into large-blocky and cloddy units. In places thin veins of carbonates are noted.

B'' 20(22)-30(35) cm Gray-brown, immature, sandy loam, friable, structureless.

B''' 30(35)-50 cm Yellowish-brownish, with occasional humus streaks, immature, coarse clay loam with sandy loam lenses, friable. Occasionally spots of salts are encountered.

B''' 50-65 cm Yellowish light brown, slightly moist, coarse sandy clay loam, with lenses of medium clay loam and sandy loam, friable, with fine veins of salts.

B''' 65-95 cm Unevenly colored horizon of nonuniform texture; has stratified layers of light brown, coarse clay loam and reddish brown clay, with lenses of yellowish gray sand. Moist, friable, with thin veins and pockets of salts (chiefly in the clay layers).

B''' 95-240 cm Red-brown, moist,

Table 6

Data from the analysis of the water extracts, gypsum, and CO_2 from soil samples for Profile No. 4

Depth, cm	Moisture	Water extract										$SO_4^=$ in HCl	$CaSO_4 x 2H_2O$ water-sol. portion accounted for	CO_2
		Solid residue	Alkalinity		Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+ by difference	Na^+	K^+			
			$CO_3^=$	Total in HCO_3^-						Determined by the flame photometry method				
	In percents for absolutely dry soil													
0—7	3.7	0.136	None	0.058	0.015	0.019	0.007	0.001	0.032	0.030	0.006	0.031	0.061	3.87
7—13	4.1	0.171	Trace	0.093	0.017	0.006	0.002	0.0005	0.045	0.048	0.003	0.035	0.052	5.63
13—20	3.9	0.202	"	0.103	0.027	0.006	0.002	0.0005	0.055	0.062	0.002	0.046	0.072	6.25
20—40	3.5	0.338	0.006	0.117	0.080	0.023	0.002	0.001	0.103	0.109	0.001	0.068	0.081	6.16
40—60	4.7	0.965	None	0.056	0.346	0.228	0.008	0.004	0.340	0.325	0.002	0.322	0.168	6.25
60—80	6.5	2.470	"	0.034	0.856	0.614	0.072	0.054	0.680	0.695	0.003	0.982	0.922	5.28
80—100	6.0	3.150	"	0.030	1.120	0.798	0.120	0.081	0.830	0.795	0.005	1.430	1.586	5.55
100—120	5.7	2.156	"	0.030	0.812	0.574	0.056	0.051	0.655	0.689	0.004	0.860	0.707	5.37
120—140	6.4	2.082	"	0.028	0.741	0.910	0.110	0.058	0.693	0.695	0.004	1.635	1.729	5.28
140—170	6.2	2.604	"	0.028	0.760	0.903	0.085	0.051	0.740	0.749	0.004	1.660	1.681	4.84
170 - 200	5.9	3.086	"	0.022	0.798	1.153	0.133	0.052	0.827	0.822	0.005	1.715	1.548	4.75
200—250	5.8	3.384	"	0.022	0.737	1.378	0.197	0.063	0.802	0.822	0.005	2.270	2.413	4.04
250—300	4.7	2.524	"	0.023	0.607	0.987	0.107	0.040	0.675	0.682	0.004	1.478	1.305	5.63
320—360	4.9	2.708	"	0.023	0.567	1.155	0.176	0.040	0.650	0.682	0.005	2.287	2.751	3.96
360—400	4.8	2.695	"	0.023	0.544	1.140	0.168	0.039	0.639	0.630	0.005	2.310	2.783	4.66
400—450	4.1	2.848	"	0.020	0.631	1.138	0.166	0.042	0.692	0.676	0.004	1.940	2.123	6.51
450—500	2.7	2.110	"	0.024	0.649	0.670	0.054	0.029	0.633	0.618	0.003	0.743	0.381	5.71
500—550	3.6	2.222	"	0.027	0.590	0.800	0.071	0.029	0.637	0.624	0.004	1.135	0.866	7.47
550—600	4.7	2.700	"	0.023	0.516	1.190	0.152	0.045	0.655	0.630	0.005	1.749	1.620	6.42
600—620	4.5	2.330	"	0.024	0.472	1.003	0.124	0.038	0.582	0.582	0.004	1.494	1.378	7.83
Ground water from a depth of 590 cm, in g/l	—	51.6	—	0.5	19.7	13.1	0.7	2.3	14.0	—	—	—	—	—

compacted, structured Araks clay, with inclusions of brown clay loam at depths of 95-130 and 220-230 cm, with rust-colored patches and salt accumulations. At a depth of 146-150 cm a dark layer of buried soil is encountered.

B''' 240-300 cm Light brown, moist, coarse clay loam, with yellowish-gray lenses of sand at depths of 260-265 cm and 280-500 cm and reddish-brown clay loam to clayey layers at a depth of 270-280 cm.

B''' 300-340 cm Light gray-yellow-brown, with rust-colored and brown patches, moist, friable, fine-grained sand.

B''' 340-450 cm Brown with reddish tinge, with dark rust-colored bands and patches and dark blue strips of gleyed, moist, clay loam to clay.

B''' 450-580 cm Dark gray with brownish tinge, damp, wet below, coarse-grained micaceous sand, with occasional inclusions of clay loam (to a depth of 500 cm). From 540 cm, water-bearing sand, aquifer.

Water table found at 580 cm depth. Effervescence from HCl observed from the surface. Along the profile from 10-160 cm there are poorly defined diffuse patches of carbonates; in places at a depth of 10-20 cm carbonates are encountered in the form of fine veins.

Profile No. 5 has the most differentiated profile. It shows a well-defined A horizon 10-15 cm thick and a columnar horizon 7-10 cm thick. The latter horizon is not very compacted; the columns easily break down into smaller units. Significant (above 0.8%) accumulations of salts are found only from a depth of 50 cm, i. e., not directly below the columnar horizon as in the previous profiles but considerably deeper. Gypsum is encountered in appreciable quantities, more than 1% $CaSO_4x2H_2O$ only from a depth of 65 cm (Table 7). Intense coloration of suspensions by phenolphthalein is observed in samples from a depth of 17-80 cm, i. e., considerably deeper than in the rest of the profiles. This indicates a more intense leaching and downward displacement of sodium carbonate originating from the interaction of exchangeable sodium with the $CaCO_3$ of the soil. In the A horizon from 0-12 cm, bicarbonates of calcium (45 eq %) and potassium (21 eq%) predominate in the composition of the salts. The role of potassium increases in exchangeable bases, reaching a value of 10% of the adsorption capacity. Small amounts of Ca^{++} and K^+ are found also in the lower-lying columnar horizon at a depth of 12-22 cm. Profile No. 5 describes the most steppe-affected solonetz, resembling a meadow-gray-cinnamon solonchak-like solonized soil. The presence in the characteristic vegetation of malcomia (Malcolmia contortuplicata), the zhabnitsa (Filago spathulata), and malvalthea (Malvalthea transcaucasica), which are ordinary species of the wormwood — meadow-grass grouping on gray-cinnamon soils indicates how deep the process of desolonetzation of the given soil has progressed. Most characteristic of the steppe-affected solonetz is lack of conformity of the morphological expression and the chemical manifestation of the solonetz characteristics. The layer from 12-22 cm possesses a morphologically expressed columnar structure; but the content of exchangeable sodium therein amounts to only 6% of the adsorption capacity. This indicates only a poorly developed solonetz. The alkalinit here is a little high (HCO_3^- content is 0.08%, pH 8.8), but it is not maximum for the profile. The most pronounced chemical manifestation of the solonetz properties is found in the layer below, from 22-35 cm, which is characterized by a friable structure and a coarser texture. The content of exchangeable sodium amounts to 39% of the adsorption capacity; the total alkalinity rises to 0.12% HCO_3^-. An alkalinity from normal carbonates appears which is not found in the columnar horizon. The quantity of CO_3^{--} amounts to 0.011%; the pH is 9.3-9.5; and sodium carbonate is the predominant member of the salt complement. Judging from the q_1:q ratio, the process of desalinization predominates in this soil. Only a certain amount of attraction of chlorides is observed in the layer from 22-35 cm.

Thus the solonetzes under consideration originate and develop as a result of the alternation of salinization and desalinization. The gradual lowering of the water table leads to steppe-soil development and desolonetzation, to the transformation of solonetzes of gray-cinnamon soils. At the same time the following changes in properties are observed: a) decrease in the degree of salinization of the upper soil layers (from 0.5-1.1% to 0.1-0.2%); b) gradual lowering of the upper boundary of the horizons that accumulate readily soluble salts and gypsum (from 20 to 65 cm); c) a lowering of the horizons with the best-pronounced solonetzic properties (from 0-10 to 20-50 cm); d) a decrease in the absolute quantity of water-soluble humus (from 0.07% to 0.03% of the weight of the soil); and e) an increase in the relative role of calcium and potassium in the upper soil layers (from 0-1 eq% to 20-45 eq %).

The downward displacement of solonetzic properties along the soil profile as the solonetzes are desolonetized during their transformation to steppe soils is a phenomenon widely distributed in nature, and this fact has been noted in the literature. It is the cause of the lack of conformity between the morphological structure and the chemical properties of the solonetzes. This characteristic may, in our opinion be used to subdivide

Table 7

Data from the analysis of the water extracts, gypsum, and CO_2 from soil samples for Profile No. 5

Depth, cm	Moisture	Water extract										$SO_4^=$ in HCl	$CaSO_4 x 2H_2O$ water-sol. portion accounted for	CO_2
		Solid residue	Alkalinity		Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	Na^+ by difference	Na^+	K^+			
			$CO_3^=$	Total in HCO_3^-						Determined by the flame photometry method[a]				
	In percents for absolutely dry soil													
0—12	2.9	0.144	None	0.058	0.003	0.007	0.011	0.002	0.011	0.005	0.010	0.035	0.050	5.01
12—22	2.3	0.150	"	0.081	0.003	0.005	0.003	Trace	0.031	0.025	0.006	0.057	0.093	6.60
22—35	2.0	0.190	0.011	0.124	0.003	0.002	None	None	0.049	0.051	0.003	0.051	0.088	5.80
35—50	1.8	0.232	0.006	0.095	0.007	0.059	0.001	"	0.068	0.072	0.002	0.104	0.081	5.89
50—65	2.2	0.838	None	0.035	0.054	0.452	0.038	0.005	0.211	0.190	0.005	0.566	0.319	5.54
65—95	2.7	1.644	"	0.032	0.293	0.663	0.053	0.011	0.438	0.422	0.004	1.165	1.081	5.98
95—130	4.3	3.836	"	0.026	1.015	1.235	0.181	0.056	0.945	0.936	0.007	2.218	2.501	5.45
130—160	5.0	3.808	"	0.026	0.918	1.394	0.186	0.062	0.941	0.945	0.008	2.360	2.492	4.40
160—200	4.8	3.248	"	0.019	0.741	1.307	0.131	0.044	0.880	0.787	0.007	2.024	1.820	4.75
200—250	4.4	3.340	"	0.032	0.946	1.117	0.101	0.045	0.958	0.883	0.007	1.528	1.124	5.37
250—300	2.6	2.144	"	0.026	0.726	0.575	0.033	0.024	0.672	0.644	0.005	0.745	0.410	5.98
300—340	2.1	1.696	"	0.032	0.564	0.445	0.018	0.016	0.540	0.459	0.004	0.506	0.141	4.66
340—400	3.8	3.044	"	0.032	0.957	0.927	0.065	0.042	0.922	0.945	0.007	1.359	1.008	5.10
400—450	4.8	3.584	"	0.026	0.988	1.226	0.119	0.056	0.995	0.857	0.008	1.910	1.700	4.13
450—500	1.9	1.348	"	0.032	0.409	0.379	0.023	0.013	0.407	0.408	0.005	0.466	0.209	3.34
500—580	1.3	1.028	"	0.032	0.386	0.256	0.017	0.011	0.344	0.314	0.003	0.301	0.169	3.25
Ground water from a depth of 580 cm, in g/l	—	47.4	—	1.0	17.5	12.3	0.7	1.9	13.1	—	—	—	—	—

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[a] Analyses of water extracts done by Ye. M. Orlova.

the meadow-steppe solonetzes according to how far along they are in their transformation to steppe soils. With this criterion in mind we can divide the meadow-steppe solonetzes of the Mil'sk alluvial plain into: a) typical solonetzes, in which the maximum content of exchangeable sodium and the maximum alkalinity are observed in the columnar horizon that is best defined morphologically; b) developing steppe soils, in which a high content of exchangeable sodium and a high alkalinity are found not only in the columnar horizon but also in the one below it; and c) developed steppe soils, in which a high content of exchangeable sodium and a high alkalinity are noted, not in the columnar horizon (the best-developed morphologically), but the horizon below it.

The carbonate nature of the solonetzes of the Mil'sk alluvial plain and the presence of gypsum at a depth of 40-50 cm gives assurance that their desolonetzation will be rapid without supplementary chemical improvement when they are put to use agriculturally with irrigation. In some cases only deep plowing will be needed (to mix the gypsum into the plow layer) together with the addition of fertilizer. To prevent the rise of ground water and the increase of salinization with irrigation it will be necessary to build a collector-drainage system. According to the data of Yegorov and Budakova (5), when ground water is drained off the flood waters of the Kura and Araks Rivers will have a meliorative effect on the solonetzes of the Mil'sk plain. Our data confirm the correctness of this conclusion. We determined the filtration capacity of one of the solonetzes (Profile No. 2, the 0-25 cm layer) with the Ostwald apparatus by the method of Antipov-Karatayev (1). The results are presented in Figure 3. The soil samples tested had strong solonetzic characteristics and percolation rate of distilled water was extremely low (curves 1 and 2). After the soil had been treated with a 0.6 N solution of $CaCl_2$, the percolation rate of distilled water increased abruptly (curves 3 and 4). In spite of the very pronounced solonetzic characteristics of this sample, the percolation rate of water from the Araks River was considerable (curve 5 and 6). This made it possible to show the meliorative effect of water from the Araks, which has an effect on the solonetzic soils similar to that of the calcium chloride solution.

Conclusions

1. The meadow and meadow-steppe solonchak-like solonetzes found in the Mil'sk alluvial plain, which are forming in the presence of an alternation of salinization and desalinization of the soils, are developing in the direction of desolonetzation and steppe-soil development being transformed into gray-cinnamon soils).

2. As steppe-soil development progresses the following changes in properties are observed: a) a decrease in the degree of saliniz tion of the upper soil layers; b) a gradual lowering of the upper limit of the horizons accumulating the readily soluble salts and gypsum; c) downward displacement of the horizons with the best-pronounced chemical manifestations of the solonetzic characteristics; d) a decrease in the absolute quantities of water-soluble humus; and e) an increase in th relative role of calcium and potassium in the upper layers of the soils.

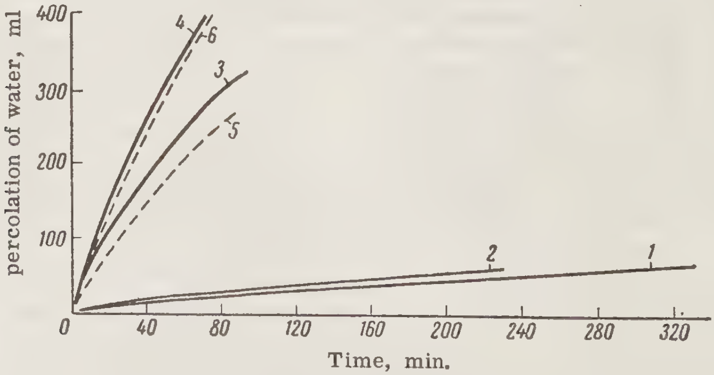

Fig. 3. - Filtration capacity of 0-25 cm, layer from a meadow-steppe crusty solonchak solonetz from Mil'sk alluvial plain (Profile No. 2).

Filtration curve: 1 and 2 - distilled water; 3 and 4 - distilled water 0.6 N $CaCl_2$; 5 and 6 - Araks River water.

3. The utilization of these soils in agricul-
re is possible with irrigation and without
pplementary chemical melioration if collec-
r-drainage systems are provided.

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DISCUSSION

THE ZONALITY OF SOILS AND THE SOIL ZONES OF KAZAKHSTAN[1]

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Zones in nature, as we know, were the subject of the final series of works of V. V. Dokuchayev, the culmination of his creative genius. The ideas of Dokuchayev are so well known that it is unnecessary to present them here.

The problem of natural zones and their further, more detailed subdivision have become subjects of special interest and have acquired particular importance as regards the proper allocation of the territory of the USSR for agricultural use. At the same time the conceptual and distributional aspects of soils are handled differently and we do not have complete agreement among soil scientists on the problem.

Thus, for example, the steppe zone is divided into two (4, 53), three (7, 40, 46), four (54), and five (15) subzones, including or excluding the forest steppe. The southern boundary of the steppe as well as the northern one are drawn differently. Many presently assign the zone of dark chestnut soils to the chernozem-steppe zone (4, 20, 40, 53, 54).

At the same time they characterize the dry steppe zone or the feather-grass steppe zone with dark chestnut soils (11, 29, 31, 33) or with chestnut and brown soils (7, 23).

One group distinguishes the desert-steppe or semidesert zone as an independent zone (4, 29, 33, 53, 54); others call it a subzone of the desert zone (42); a third group omits it (7, 15, 31, 39); a fourth group considers it as a synonym for the dry steppe zone (40); a fifth group distinguishes it as a zone of brown and gray-brown soils (8, 11). One school of opinion assigns light chestnut soils to this semidesert zonal group (4, 33, 45); others, light chestnut and brown soils (20, 29, 43, 53, 54), dividing the desert-steppe zone into two subzones (6, 53).

Let us note a few statements of various authors.

A. A. Rode (40) distinguishes zones ("belts of ordinary chernozem, southern chernozem, and dark chestnut soils within the steppe zone About the latter he writes: "These [dark ches nut, — Sokolov] soils often are united with th light chestnut soils into an over-all zone of chestnut soils. But since the dark chestnut soils are very close to the chernozems in vegetation and forest characteristics, we incorporate the dark chestnut soils with the chernozems which is in agreement with Acade mician L. S. Berg, Prof. S. S. Neustruyev an Prof. G. M. Lavrenko" (p. 415).

N. N. Rozov (42) is of the opinion that the concepts of soil and soil and soil-agronomic regional division do not coincide, and he sets up two parallel divisions: 1) soil zones and subzones; and 2) soil-agronomic belts (zone and subzones.

The first (soils) separation, based on the old standard conception of soil groups and zones, of gray forest soils, chernozems, chestnut soils, brown soils, etc., is not considered by Rozov to be entirely satisfactory; but in his opinion the traditional framework o soil groups has gained such broad acceptance that it would not be sensible to eliminate it now. In the scheme of Zakharov (23) there are subzones. The chestnut and brown soils are united into one chestnut-brown zone. Th sierozem zone is considered to be horizontal (latitudinal).

The soil scientists of Uzbekistan (38) mak a clear division of the earlier "gray zone int a vertical zone of sierozems and a flatland-latitudinal zone of desert" (p. 104). They interpret the concept of sierozems very broadly; includes soils with humus contents above 5% which are found on mountain slopes under rushwood-herbage-mixed grass steppes.

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[1] The basic theses of the article were stated in a speech delivered to a session of the Kazakh division of the All-Union Society of Soil Scientists in Alma-Ata in March 1958.

A. M. Rozanov in his monograph defines the ierozem zone somewhat differently from the enerally accepted concept. His sierozem zone" encompasses two zones[2] in the ordinry interpretation: the desert and the desert-teppe, which he calls regions. In this conection he distinguishes as special groups the esert sierozems and the sierozems (proper).

Dobrynin's scheme (15) omits the brown soils nd the brown zone. The light chestnut soils he escribes as characteristic of the grass-wormood and wormwood-saltwort semidesert, but semidesert zone is not distinguished.

We shall attempt to look into all these conradictions. First of all it is necessary to stablish definite principles which, in our pinion, should be followed in this case.

The first principle, derived from the ideas f the founders of soil science, V. V. Dokuhayev and N. M. Sirbirtsev, and developed in e works of S. S. Neustruyev, S. A. Zakharov, . I. Prasolov, and others, holds that soil, s a natural — historical body and a means of roduction, cannot be separated from the georaphical circumstances of its location. In is it differs basically both from living natural bjects — plants, animals, and microorganisms and from natural lifeless objects — rocks and inerals; we have discussed this point already 2). Hence the natural general classification soils can only be geographical-genetic and, sofar as this is possible with our present vel of knowledge, evolutional-geographical-enetic.

The second principle may be stated thus: e principal classification units of normal ccording to Dokuchayev) soils, i. e., zonal, tomorphic, with moisture from the atmosere, of an eluvial series — should correspond so to definite geographical units of soils. The il group and soil zone, the soil subgroup and il subzone, respectively, are such units.

This idea is also developed by Zavalishin his works (21, 22). Only neglect or nonceptance of this principle could have led, in r opinion, to the differences in the interpretion of soil zones and subzones.

The third principle, which we consider as tremely necessary, is the conformity of the ncepts and limits of the natural (geographil and landscape), soil, and agricultural nes and subzones. This is rejected by some thors and the result is much misunderstandg.

On the basis of these considerations we shall try to analyze the factual materials. In this paper we shall not spend time on the northern zones which are not found on the plains of Kazakhstan.

The necessity of distinguishing the forest-steppe as an independent zone, in our opinion, cannot be questioned from the point of view of the soil scientist.[3] But serious difficulties arise in subdividing it into subzones and in applying the basic principle of matching concepts. First of all, we find that in the forest-steppe zone there are two zonal groups — gray forest soil and chernozem.

Concerning the degraded (podzolized) chernozems (50), here the solution to the problem is simple. These soils should be assigned to the forest-soil group, more precisely, to the deciduous-forest soils (chernoles'ye)[4] as distinct from the podzolic soils of coniferous forests. It is not necessary now to prove this proposition. But many, we find, assign to the forest-steppe zone also the zones where rich, thick chernozems predominate. These soils are unquestionably of the steppe group and also have been designated in recent classifications as typical chernozems; this is not, to our mind, a very happy innovation. It is evident that a soil group of one zone cannot be zonal in another "alien" zone. We do not think it is possible to assign to the forest-steppe zone areas of rich thick chernozems nor even less the average (ordinary) chernozems of Siberia, even though from the standpoint of landscape this has some basis.

Thus, by forest steppe we should understand the zone of predominantly gray forest soils and degraded chernozems, i. e., soils of the deciduous-forest group. Dividing them into subzones will depend on how we set up the subgroups in a given group. Ordinarily two or three subgroups of gray forest soils are distinguished: light gray and dark gray or true gray. Altogether, then, we have three or four subgroups (when we include degraded chernozem). But distinguishing four or even three subzones in a relatively restricted zone is scarcely justified. Hence it seems reasonable to us to broaden both these concepts, reducing them to two: 1) light gray and gray soils (northern subzone); and 2) dark gray soils and degraded chernozems (southern subzone).

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[2] Not to mention the higher mountain regions, where zanov also finds traces of sierozem formation.

[3] The independence of the forest-steppe zone was conclusively proved in the works of Mil'kov (34, 35).

[4] This term chernoles'ye used for 900 years, designates a deciduous forest. The term has now fallen into disuse and is not understood by many. Deciduous-forest is the preferred term.

In Northern Kazakhstan and to some extent in Western Siberia the forest steppe has a special character, since intrazonal soil groups prevail there — the meadow-chernozem and the solods.

The problem of the leached chernozems remains unsolved. Long ago we expressed the idea (49) that they do not have their own subzone and therefore must be eliminated as a subgroup and put in the category of a genus, just as the carbonate, solonetz-like and solodized chernozems.

In the steppe zone, it seems, there is a disagreement as to the division into subzones of the ordinary (central, average humic) and southern (slightly humic) chernozems with their corresponding subgroups. We have already mentioned previously the necessity of including in this subzone the subzone of thick, rich chernozem. On the southern side many authors combine the subzone of dark chestnut soils to the steppes, and this seems to us to be justified and proper from both the scientific and the production points of view. Apparently this opinion was first advanced by Gerasimov (8), who distinguished the following soil groups: chernozem (normal chernozem); chernozem-chestnut (southern chernozem and dark chestnut soils); light chestnut; brown; and desert-sierozem.

But then, again, according to the principle adopted, the dark chestnut soils should be assigned to the chernozem group as a subgroup. This idea was pointed out by us more than 20 years ago. "The dark chestnut soils in their characteristics are closer to the southern chernozems than to the chestnut soils and should be referred to the soils of the chernozem-steppe zone. It would undoubtedly be more correct to call them chernozems (chestnut, chocolate, or something else)" (48).

The chestnut (proper) soils, which do not constitute everywhere a clearly expressed, tight zone, nevertheless are closer to the dark chestnut soils, where they should also be placed. Setting them up as a special subgroup with a special subzone does not seem appropriate.

Thus we propose dividing the steppe zone into four subzones: 1) northern (rich and thick) chernozems; 2) central chernozems; 3) southern chernozems; and 4) dark chestnut soils.

Since the renaming of soil groups and subgroups naturally encounters many objections and difficulties by virtue of the unavoidable conservatism of our ideas, and since it is not desirable to depart from the accepted and understood nomenclature, the steppe zone may still be called chernozem-chestnut. We do not think it justified to distinguish a special zone of dry steppes with a dark-chestnut soil group, since the difference between dark ches nut soils and southern chernozems is not larger but rather smaller than that between the latter and the central chernozems.

The desert-steppe or semidesert zone is hardly the subject of minimum disagreement among soil scientists regarding what it includes, its boundaries, and even the very necessity of distinguishing it. Here, doubtlessly, we feel the influence of the botanists, most of whom reject the notion of a semideser by reason of the absence therein of a particula type of vegetation (it has a mixture of the step and desert types).[5] There is no doubt that, as regards soil, vegetation, economic use, and finally, extent within the USSR, the desert-steppe zone has no less reason for existence than any other. The question of the brown semidesert soils is the least clear aspect.

The history of the brown semidesert soils is well enough known. We shall mention only that the instigator of the "liquidation" of the brown soils was the botanist Abolin, who suggested elimination of the terms "brown zone" and "brown" and "light brown" soils (1). He was supported by Bezsonov (2). This viewpoint, as we know, subsequently gained the support of almost all Soviet soil scientists. After some two decades the name brown soils reappeared, and now all refer to them under the name brown desert-steppe (not steppe) soils, but their systematic and geographical position has not been clear. Some authors point out the close relationship of the brown soils to the light chestnut soils; others indicate their affiliation with the typical desert soil formations.

We think that both are correct and at the same time, somewhat incorrect. This apparent contradiction is explained, evidently, by the fact that different authors are talking abou different brown soils. This was virtually the basis for Abolin's position. He suggested dividing the brown zone into two parts: one was to be assigned to the light chestnut, the other to the sierozem. But in rejecting the existence of the brown soils as a group, Abol ignored their very clear subgroup-level difference from the light chestnut soils on the o hand, and from the desert sierozems on the other.

Even before the period of the "liquidation" of the brown soils and the brown zone, at the time when science had a fairly limited amoun of data available, especially of an analytic

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[5] The first most complete description of the semidesert was given by the botanist Keller together with the soil scientist Dimo (14).

ure, Glinka pointed out the difference of the
own soils (12). Even in his early work he
nd that the humus content in brown soils,
ounting to 2.5%-3%, decreased toward the
ıth to 1% or even less. In a later work
nka stated directly: "The brown soils form
 subzones: a northern one with dark brown
ls and a southern one with light brown soils"
, p. 24). For these and others he gave very
evant profile descriptions.

Now we could present a series of analyses
show the correctness of the position of
nka. No less eloquent are the climatic
exes. Can we assign to one and the same
ıe regions in which the annual total precipi-
ion amounts to almost 200 mm (for example,
lmykovo -193 mm) and regions where it
ps to 100 mm or less (Buru-Baytal, 81 mm),
se to the lower limit for the whole USSR?
idently not.

Recently Nikitin (37) divided the brown
ls into northern and southern types for the
spian lowland, but he assigns them, as did
nka, to a single desert zone. In contrast,
idland (6) assigns the entire northern Caspian
land to the semidesert zone, dividing it into
 subzones: 1) a grassy-semishrub zone on
ht chestnut soils; and 2) a semishrub zone
brown soils. We cannot help agreeing with
reasoning of the author.

We have no doubt that the brown soils as
sently constituted do not represent one
up and one zone. The northern or dark
wn soils must be referred to the desert-
ppe zone to make a single group with the
ht chestnut soils, and the southern or light
wn soils must be assigned to the desert
ne, combining the desert sierozems (and
y-brown soils).

Thus the desert-steppe zone includes, as
see it, two subzones: 1) the light chestnut
ls and 2) the brown (dark, northern) soils.
again, not to resolve prematurely the
stion of changing the names of soils, we
y assign to the zone the designation chest-
-brown.

Let us turn to the last horizontal zone, the
ert zone. We have already referred to the
itions of A. N. Rozanov and the soil scien-
s of Uzbekistan. Recently Lobova (31, 32)
roduced a new concept according to which
gray-brown soils constitute the zonal group
the deserts of the USSR. This view agrees
npletely with the basic principle of confor-
y of soil group and soil zone and elimin-
s much misunderstanding. For this it
 only necessary to broaden considerably
concept of gray-brown soils, against
ich it, in principle, is difficult to object.
h an extension was already made earlier
).

As for the gray-brown soils in the old, narrower concept, i. e., the gypsiferous, they should be referred to the intrazonal series. According to our observations, in Alma-Ata and Taldy-Kurgan regions the gypsiferous gray-brown soils are found not only in the desert zone but also in the semidesert piedmont zone to an absolute elevation of 1200 m, where the light chestnut subzone is already beginning. The origin of the horizon of columnar gypsum has already been explained in part by Rozanov, and recently very convincingly by Minashina (36) with respect to the gray-cinnamon calcareous soils of the Transcaucasus, which are similar to the gray-brown soils. The accumulation of gypsum is the result of the transport and accumulation of the weathering products of the original rock, which are rich in sulfides (pyrite) and basic sulfates of the alunite type.

And what are the "subzonal" subgroups of the desert zone? The majority of investigators divide the desert zone into subzones of northern and southern deserts. This division is substantiated convincingly in the works of Korovin and Kashkarov (28) and Rozanov (41). But it must be better defined, since in these authors the desert zone is understood within limits that are too broad, including the brown soils in general (with the "dark brown") on the north and the piedmont sierozems on the south. The soil subgroups of the desert zone are still not completely clear. Apparently they are as follows: 1) The subzone of northern deserts — brown (light) soils; 2) The subzone of southern deserts — the desert sierozems of Rozanov, the desert group of the soil scientists of Uzbekistan.

The question of renaming the soils, in particular the desert sierozems, we leave open.

On the south the desert plains of the USSR abut the foothills of the Caucasus, the Kopet-Dag, and the Pamir-Alay and Tyan'-Shan' mountain systems, where the soil-vegetation-climatic zones assume, as it were, a reverse orientation. The transitional boundary of the horizontal zones of the plains to the vertical zones is not clear and up to now has been the cause of much misunderstanding. We had the opportunity to set forth our thoughts briefly on that score (52). We shall attempt to develop them in somewhat more detail.

Any mountainous area, considered as a whole, shows decomposition (disintegration, solution, etc.) of its component rocks. This, obviously, does not exclude local, limited, and temporary accumulations on the lower portions of the slopes, canyons, and ravines, valleys of mountain rivers as well as glaciers and perhaps aeolian accumulations (47).[6]

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[6] In the mountains ancient accumulative forms may be preserved.

The products of the disintegration are carried immediately to the lower areas by surficial (permanent and temporary), soil, and ground water as well as by the wind. The forms of relief are continuously being changed and perhaps renewed. The process of soil formation also follows a corresponding course. This process may be called a typical eluvial process with a leaching water regime even under relatively dry conditions, since conditions for the appearance of ascending currents are excluded. The soils are continuously renewed by washout. The eluvial process is countered only by the purely soil-related process of biological accumulation. Soils differ (often very markedly) on slopes of different exposure.

The piedmont-foothills region may be characterized in general as a zone of transition or alternating removal and accumulation. It receives a mass of fine-grained (loess) and coarsely fragmented (gravel, pebbles) material which often forms thick strata. Dissolved weathering products as a rule are not deposited here. But under certain special conditions, in arid regions, it is apparently possible for subsoil lime and gypsum as well as silicaceou and ferruginous accumulations to form. It is probable that these are relics of ancient processes that took place under other topographica conditions. The soil process occurs under th weaker eluvial regime which may appear with drier, non-leaching conditions; this governs the carbonate content of soils and soil materia Soils form as the soil stratum builds up throu the accumulation of materials from the mountains, usually humified to some degree, and acquire a thick profile, of course, where the fine-grained material is thick enough.

What we have said is completely applicable only to the sloping piedmont plain. For the foothills (terraces) this stage has passed, but their soils still retain traces of the piedmont cycle of soil formation. Large intermountain depressions and depressed plains lying at the foot of the mountains stand out as regions of accumulation.

Table 1

Soil zonation in the southern regions of the Kazakh SSSR

Indicators	Horizontal (on plains remote from the mountains)	Horizontal-vertical (on piedmont plains and foothills	Vertical (in mountains)
Leading physical-geographical processes	Weak eluviation with shift of products of disintegration to lower horizons	Moderate eluviation, partly compensated by addition from higher relief elements	Strong eluviation with removal of products of disintegration to lower areas
Transport of solid material	Absent or poorly defined	Accumulation; partly en-route transfer	More or less intense removal
Transport of dissolved weathering products	Shift within profile of more soluble products	En-route transfer and partly accumulation of the more stable compounds — carbonates and sulfates of calcium, compounds of iron and silicon	Removal of all products of weathering
Type of soil-water regime	Non-leaching	Weakly leaching and partial subsoil leakage	Very pronounced leaching
Structure of the soil profile	Normal profile with clear separation of horizons	Accumulative (built-up) profile with unclear, distended horizons	Abbreviated (eroded) profile, often incomplete, without leaching horizons
Effect of slope exposure on soil formation	Absent	Expressed weakly only on high dissected foothills	More or less clearly expressed
Complexity of soils according to microrelief	More or less clearly expressed	Rarely found in the lower portions	Absent

The piedmont-foothill regions differ from
plains and mountains above all by a special
of zonation. If on the plains the succes-
of zones occurs according to an over-all
nge of climate in a meridional or near-
idional direction, and in the mountains ac-
ding to absolute elevation, yet on the pied-
t plain the governing factor is the distance
n the mountains and the structure of the
cent mountain system. Although proximity
ne mountains is also accompanied by in-
ased elevation, as a rule, the elevation
es here ordinarily are too small to cause
oticeable a shift. Slope exposure has
e effect on soil formation. This, without
bt, is a special, third type of zonation,
ch may be called horizontal-vertical. As
know, piedmont sierozems also have their
special climatic regime with marked
sonal moisture differences — maximum
cipitation in spring and extreme dryness
ummer. For the sake of clarity, what we
e said is presented in Table 1.

To the scheme of vertical zones we add one
il. Earlier, (50) in agreement with many investigators, we divided the one mountain-forest vertical zone into two subzones or regions: 1) the coniferous and 2) the deciduous forests. Now it is evident that the mountain-forest vertical zone should be broken down into two independent zones, since the dark-colored, partly podzolized mountain-forest soils of the aspen and pomaceal forests. In general the soil zones of Kazakhstan take the following from (Table 2).

In southern Kazakhstan, just as also in Central Asia, the light chestnut piedmont-foothills soils are replaced by dark sierozems. The dark chestnut and chernozem soils of the piedmont are usually heavily cultivated, leached genera, transitional to the special "orchard" soils. Naturally all this is only a general outline. We know that the actual picture of the soils is far more complicated and is determined not only by the zonal laws but also by the local geology and geomorphology, by the age and developmental history of the relief, soil-forming parent materials, and soils, and also by the activity of man.

Table 2

Scheme of soil zones and subzones of Kazakhstan

Zonality		
Horizontal	Horizontal-vertical	Vertical (for the Tian-Shan system)
—	—	Snowy
—	—	Mountain-meadow; Subzones: 1) alpine mountain-meadow soils 2) subalpine mountain-meadow soils
—	—	Meadow-forest, dark-colored, partly podzolized mountain-forest soils
est-steppe (predominance of intrazonal soils)	—	Forest-meadow-steppe deciduous-forest soils
Steppe Subzones: central chernozems southern chernozems	Steppe Subzones: chernozems dark chestnut soils	Steppe Subzones: chernozems, dark chestnut soils
Desert-steppe Subzones: ight chestnut soils dark brown soils	Desert-steppe Subzones: light chestnut soils ordinary sierozems	
Desert Subzones: ight brown soils desert sierozems	Desert Subzones: light sierozems	

The boundaries of most of the soil zones and subzones of Kazakhstan, even though variously interpreted, are now fairly well established. To compile a map of the soil zones we need only set a new boundary for the semidesert and desert and distinguish the piedmont soil-formation series. This requires a critical examination of descriptive and analytical data on the brown and piedmont soils.

The establishment of zones and subzones is only the first stage in the natural regional analysis, which has as its final goal the proper planning in the light of natural conditions of the different branches of the peoples' economy, and in the first place of agriculture. The fundamental condition for raising the agricultural level is increasing the fertility of the soil. The methods of increasing fertility may have a very different character according to their application to these or those natural conditions. Kirsanov (27) distinguishes these elements: 1) super-regional; 2) broadly regional; 3) narrowly regional; and 4) narrowly individual. We can, without changing the essential point, divide the means of increasing soil fertility thus: 1) superzonal; 2) zonal; 3) subzonal (applicable only within one subzone); 4) regional; and 5) local.

If we do not divide the zones correctly, and if we confuse zones with subzones, we necessarily incorrectly set up and recommend means for increasing soil fertility. A method that is good in one zone or subzone may be ineffective in the neighboring zone. This also applies to the regional planning of agricultural crops, to the utilization of hay crops and pastures, to the selection of tree species, etc.

Dokuchayev's doctrine of agricultural zones and his doctrine of natural zones should be studied and extended to fit our conditions.

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METHODS

PID METHODS FOR DETERMINING MICROELEMENTS AVAILABLE PLANTS IN SOILS

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itil recently, determining the available s of microelements in soils has been an ptionally complex and laborious operation ring expensive equipment and hard-to-get ents. In view of this, we directed our atten- o the problem of developing simpler meth- vhich would be practical for large-scale but, at the same time, be accurate enough ermine the microelements (Cu, Zn, Mn, Mo, and B) available in soils. Only those oelements whose practical value in agri- re has been established were selected.

rst of all, problems arise as to what forms croelements in soils are considered as able, and to what degree they are assimi- by plants. In connection with this, what nts must be used to leach these micro- ents from the soils. In solving these ems, we proceeded from the fact that it actically impossible to select a solvent vould completely match the absorptive ca- of plant root systems. We are however, o select the most available compounds of icroelements that are assimilated to a in degree in soils. These compounds, as nerally known, enter solutions of weak acids, neutral salts, or water extracts.

comparing analytical data with data from experiments in which microelements are to various crops, it is possible to establish tant correlations between the amount of oelements in the soil and the effectiveness croelement fertilizers. The data obtained be used in regionalizing the use of micro- ents in agriculture.

accordance with our previous investiga- weak solutions of HCl, H_2SO_4, and HNO_3 used to extract copper, manganese, and from the soil; a normal solution of potas- chloride was used to extract zinc; an oxa- olution at pH_3 was used to extract molyb- ; and a water extract for boron. Other tigations also use these solvents. With ception of the boron, a soil-solvent ratio was adopted to determine all microelements, and the soil was allowed to interact with the solvent for 30 minutes. The ratio was 1:3 for the boron, and the soil was allowed to interact with water for 5 minutes with boiling. It was found that there was no practical need to increase the reaction time of the soil and solvent for the majority of the microelements entering the acid and salt extracts.

During the development of the analytical technique we tried to: a) obtain a clear and well-defined coloring of solutions for colorimetric analysis; b) create reaction conditions that would eliminate the effect of ions and materials interfering with the analysis; c) determine each microelement in the presence of any other microelement in the same soil extract; and d) conduct the analysis under conditions encountered on the kolkhoz and sovkhoz, as well as on soil expeditions.

A description of the analytic technique used for each of the foregoing microelements follows.

Copper

Methodology. A new version of the colorimetric method for determining copper was developed by using dithizon. A complex buffer solution composed of sodium acetate, sodium phosphate, and potassium thiocyanate was used in this version to promote a quicker and more complete reaction of the copper with the dithizon. Iron is separated by precipitation with ammonia. The extract is simultaneously fried of organic material hindering the analysis.

In an acid medium copper and dithizon produce compounds in a keto from which have a red color. We utilized the possibility of analyzing the red dithizonate of copper colorimetrically without separating the excess dithizon.

Analytical Technique. 5 g of soil or 2.5 g of peat is placed in a 100-ml flask; 25 ml of 1N

HCl are added and shaken for 30 minutes. The extract is filtered through folded filter paper. 10 ml of the filtrate is placed in a test tube marked at 20 ml, one drop of a 1% phenolphthalein is added and neutralized with twice-diluted 25% ammonia until the liquid assumes a rose-colored hue. Distilled water is added to the test tube to make 20 ml; the liquid is shaken and filtered into another test tube of the same type. 0.5-5 ml of the liquid is taken from the resultant filtrate (second filtrate), depending on the copper content, and placed in a test tube 16 mm wide with a ground-glass stopper. 2 ml of the complex buffer liquid are added and the reaction of the solution is brought to pH of 2.0 as shown by a universal indicator (test paper). Then a solution of dithizon in carbon tetrachloride is added in an amount of 1.0-7.5 ml (depending on the copper content) and shaken rapidly for 0.5-1 minutes until the color persists. The copper forming the copper dithizonate is extracted in the CCl_4 layer. This colored layer is compared with a known test scale. It is important to determine the optimum quantity of the extract to be used for the analysis so that the color of the solution analyzed can be found within the limits of the previously prepared standard scale. When conducting an analysis by the method cited previously, it is recommended that 5 ml of extract and 1 ml of dithizon solution be used at first. If there is very much copper in the extract and the dithizon layer has a darker red color than the last test tube of the scale, then more dithizon is added to the test tube so that the total quantity of this reagent is 2.5, 5.0, or 7.5 ml. The test tube is shaken vigorously after each addition of dithizon and then compared with the scale. The analysis is repeated with a new sample of extract — 1.0 or 0.5 ml — if the reddish color exceeds the limits of the scale after agitating with 7.5 ml of dithizon.

If, when analyzing 5 ml of extract (second filtrate) with 1 ml of dithizon added, the liquid being tested colorimetrically takes on a darker green color than the first test tube of the scale (which indicates insignificant amounts of copper in the solution), the analysis must be repeated with 10 ml of the second filtrate.

The analysis is computed by the formula:

$$x = \frac{a \times b}{c \times d} 10{,}000$$

where x is the copper (Cu) in mg per kg of soil; a is the Cu in mg in 5 ml of dithizon in the corresponding test tube of the scale; b is the quantity of dithizon in ml used for the analysis; c is the weight of the second filtrate in ml used for the analysis; and 10,000 is the coefficient to convert the analysis in mg per kg of soil.

Prepare an original and a working solution when readying the scale of known solutions. Prepare the known copper solutions in test tubes 16 mm in diameter, keeping in mind th test tubes of the same diameter will be used during the analysis. The initial solution contains 3.923 g of $CuSO_4 \times 5\ H_2O$ in 1 liter of acidified distilled water. This solution contains 1 mg of Cu per ml.

The working solution containing 0.001 mg Cu per ml (1·γ per ml) is prepared from this solution and placed in test tubes according to the following scheme:

Test tube No.	1	2	3	4	5	6	
Quantity of working solution, ml	0.0	0.5	1.0	1.5	2.0	2.5	3

Two ml of the complex buffer liquid are added to the copper solution and the reaction brought to pH 2 according to test paper; 5 m of dithizon are poured into each test tube agitated rapidly for 0.5-1 minute (until the colo is permanent). The solutions being analyzed are compared with the prepared test scale.

Reagents

1. Dithizon Solution. Dissolve approximat ly 0.01 g of dithizon in 50 ml of CCl_4 and filte Add 50 ml of NH_4OH (1:20) to the filtered dit zon solution in a 200-ml separately funnel an agitate; the water layer remains yellow, indi cating an alkaline reaction. Remove the low layer of CCl_4 and wash the water solution tw or three times with 5-10 ml of pure CCl_4, ag tating both liquids each time; then, after the layers separate, the CCl_4 forming the lower layer is drained off. Then add about 25 ml o 1N HCl so that the color of the solution remains green (acid reaction) and another 50 or so are added. The dithizon enters the CC layer with shaking. The approximate concen tion of dithizon used in the analysis is 0.001%

2. 1N HCl. Dilute 82 ml of concentrated HCl (specific gravity 1.19) with distilled wat to a volume of 1 liter.

3. 1% Solution of Phenolphthalein. Dissol 1 g of phenolphthalein in 100 ml of 96° ethyl cohol.

4. NH_4OH (1:1). Mix one volume of 25% a monia with one volume of distilled water.

5. NH_4OH (1:20). Mix one volume of 25% ammonia with twenty volumes of distilled wa

6. Complex Buffer Solution. Dissolve 15 of sodium acetate, 7.5 g of Na_2HPO_4, and 2. of KCNS in 40 ml of distilled water; acidify

tion with concentrated hydrochloric acid to
1.5-2.0 (determined by indicator paper) and
add liquid to make 100 ml.

. CCl_4, pure.

Zinc

Methodology. We take into account that
paratively little organic material or ions
ther metals which interfere with the de-
nination of zinc enter into a 1N solution of
in the version of the dithizon method de-
ped to determine the exchangeable zinc in
s. The buffer solution of sodium acetate
sodium thiosulfate that we used eliminates
possible effect of small amounts of copper,
cury, silver, gold, bismuth, lead, and cad-
m ions on the results of the analysis. These
are never found in 1 N KCl extracts from
s in amounts to interfere with the determina-
of zinc. Colorimetric analysis of the red-
red zinc dithiazonate is done without separ-
g the excess green dithizon. Each vessel
l to determine zinc must be washed with a
tion of dithizon in carbon tetrachloride
then with distilled water purified with dithi-

nalytical Technique. Place 5 g of soil or
g of peat into a 100-ml flask; add 25 ml of
I solution of KCl purified with dithizon; and
shake for 30 minutes. Then pass the ex-
t through a filter cleansed of zinc by wash-
with 0.1 N HCl and distilled water from which
races of zinc have been removed by dithizon.
e 5 ml of the filtrate into a 16-mm test tube
a ground-glass stopper, and then add 2.0
f the complex buffer solution of sodium ace-
and sodium thiosulfate. Cleanse the buffer
tion first of any traces of zinc. After adding
buffer solution, bring the pH of the liquid to
(according to a universal indicator — test
r or gamma-dinitrophenol) with 0.1N HCl
:20 NH_4OH. Then add a 1 ml of a solution
thizon in CCl_4 prepared the same as when
rmining copper, to the test tube. Shake the
d for 0.5 minutes and then compare the
red layer of dithizon in the tube with the
n test scale. Repeat the shaking and com-
son with the scale until a permanent color
tained and then mark the final figure. A
lar operation is conducted in so-called
nk" determinations to check the purity of
ents and the cleanliness of vessels. If
e is much zinc in the solution analyzed and
dithizon solution in the test tube has a darker
color than the last test tube of the known
e, add more dithizon to the test tube so that
otal volume in it is 2.5 ml. The volume of
zon solution added may be increased to 5.0
.5 ml if necessary (when there are large
tities of zinc). Shake the liquid in the test
rapidly after each addition of dithizon and
e the next comparison with the known test
scale. If with 7.5 ml of dithizon the color of the liquid in the test tube is redder than the last test tube in the scale, repeat the analysis using only 1.0 or 0.5 ml of the filtrate, instead for 5 ml, for the determination.

Also, if the liquid in the test tube has a darker green color than the first test tube in the scale (which indicates insignificant amounts of zinc in the solution) when analyzing 5 ml of the filtrate with 1 ml of dithizon added, it is necessary to conduct the analysis again using 10 ml of filtrate and 1 ml of dithizon. The results of the analysis may be computed by a formula similar to the one used to compute copper, but in this case the coefficient to convert mg per kg of soil will be 5,000 instead of 10,000. When the ratio of the soil to the solution is 1:10 (peat soils), the results of the analysis will be multiplied by two.

Prepare an initial standard solution with 0.1 mg of Zn per ml. To prepare this solution, dissolve 0.1 g of chemically pure metallic zinc in zinc-free distilled water and acidified with 1 ml of concentrated H_2SO_4. Increase the volume of the liquid to 1 liter with zinc-free distilled water. Prepare the known working solution containing 0.001 mg of Zn per ml of solution from this initial solution by diluting it 100 times with water. Pour the solution into the corresponding test tubes in the following amounts in milliliters to prepare the scale:

Test Tube No.	1	2	3	4	5	6	7
Volume of working solution, ml	0	0.25	0.5	0.75	1.0	1.25	1.5

Raise the volume of the liquid in each test tube to 5 ml with a 1N zinc-free solution of KCl, and then add 2 ml of the complex buffer solution and 5 ml of dithizon dissolved in CCl_4. Therefore each test tube γ of the scale will differ from its neighbor by 0.25 γ of zinc. If we consider that it is rather easy to tell an intermediate value in the solution analysed when comparing it with the scale, then the accuracy of the analysis in absolute values will be 0.1 γ of Zn per 5 ml of dithizon solution.

Reagents

1. Dithizon. Prepare as when determining copper.

2. 1N KCl. Dissolve 75 g of KCl in distilled water; increase the volume to 1 liter; and cleanse it from any traces of zinc with dithizon.

3. Complex Buffer Solution. Dissolve 40 g of sodium acetate and 40 g of sodium thiosulfate in distilled water; increase the volume of the

liquid to 200 ml and cleanse with dithizon.

4. 0.1 N HCl. Increase 8.2 ml of concentrated HCl to 1 liter with distilled water cleansed with dithizon.

5. NH_4OH (1:20). Mix one part of concentrated 25% ammonia with 20 parts of distilled water cleansed with dithizon.

6. CCl_4. Carbon tetrachloride. Cleanse the distilled water and salt solutions by shaking them in a separatory funnel with a solution of dithizon in CCl_4. Drain off the lower layer of the liquid each time. Continue the treatment with dithizon until the green color is permanent. When using purified reagents it is necessary to add a little dithizon solution to them and shake periodically.

Manganese

Methodology. Bivalent manganese, moving from the soil into a solution of 0.1N H_2SO_4, is acidified with persulphate and analyzed colorimetrically in the form of the permanganate with a scale of knowns.

The H_3PO_4 is added to remove the color of trivalent iron — its colorless compounds are formed as a result. Organic material is oxidized simultaneously with the oxidation of the manganese. The colorimetric analysis is made immediately after the oxidation.

Analytical Technique. Treat a 5-g sample of soil or 2.5 g of peat in a 100 ml flask with 25 ml of a 0.1N solution of H_2SO_4 for 30 minutes with periodic shaking. Then filter the extract; place 10-20 ml of the filtrate into a 50 ml flask of heat-resistant glass; and then evaporate to an approximate volume of 7 ml. Then add 0.3 ml of concentrated H_2SO_4, 0.3-0.5 ml of 85% H_3PO_4, and 1 ml of 2% $AgNO_3$; then, after heating to the boiling point, add small quantities of $(NH_4)_2S_2O_8$ (approximately 0.6-0.9 g in all) two to three times.

When the liquid takes on a permanent rosy color, pour it into a 16 mm test tube, add distilled water to bring it to 10 ml, and then compare it with the known test scale. If there is much manganese in the extract and the intensity of the color of the solution analyzed is greater than that in the last test tube of the scale, dilute the solution several times (2, 3, 4, 5, or 10 times) so that the color does not exceed the limits of the known scale.

If the soil extract contains much organic material (strongly colored), take 10-20 ml of the extract; evaporate to dryness, add 2-3 drops of concentrated H_2SO_4; and oxidize with 1-2 ml of H_2O_2, evaporating until the fumes of sulfuric acid appear. If the residue in the flask has still not completely bleached, repeat the oxidation once or twice again, adding 0.5 ml of H_2O_2 and evaporating each time. After oxidizing, dissolve the residue in 0.3 ml of concentrated H_2SO_4 and 5 ml of distilled wate while heating. Then the analysis is conducte as described previously, beginning with the addition of the H_3PO_4.

The results of the analysis are computed b the following formula;

$$x = \frac{a \times b}{c \times d} 2{,}500$$

where x is Mn in mg per kg of soil; a is the M content in mg in 10 ml of solution in the corresponding test tube in the scale; b is the volume of the colored solution analyzed, in ml; c is the weighed portion of soil used for the analysis, in g; and d is the volume of the soil extract analyzed, in ml.

When the soil-solution ratio is 1.10, the fi values of the analysis will be multiplied by tw

Prepare the initial solution for making up test scale of knowns by dissolving 0.505 g of $MnSO_4 \times 7\ H_2O$ in 1 liter of distilled water containing 5 ml of concentrated H_2SO_4. This solution contains 0.1 mg of Mn per ml.

Prepare the known solutions in 10 identica 100-ml flasks. Pour 0.5-9.0 ml of the initial standard solution into each flask. Then add up to 50 ml of distilled water, 3 ml of concentrated H_2SO_4, 3 ml of 85% H_3PO_4, and 2 ml of 2% $AgNO_3$; add a little $(NH_4)_2S_2O_8$ three times while boiling. Then increase the volume of the liquid to 100 ml with distilled water. Pou these solutions from the flasks into a series of test tubes with 10 ml in each.

Reagents

1. 0.1N H_2SO_4. Add 2.8 ml of concentrated H_2SO_4 (specific gravity 1.84) to 1 liter of distilled water.

2. Concentrated H_2SO_4.

3. 85% H_3PO_4.

4. 2% $AgNO_3$.

5. $(NH_4)_2S_2O_8$.

6. 30% H_2O_2.

Cobalt

Methodology. The cobalt is extracted fro the soil by 1N HNO_3. Considerably less iron, which interferes with the analysis, enters th eak solution of nitric acid. Organic material nd bivalent iron are oxidized by hydrogen perxide and $KMnO_4$. The iron is bleached by hosphoric acid. Cobalt is analyzed colorietrically in the form of a compound with a itroso-R salt.

Analytical Technique. Place 10 g of soil or g of peat in a 100-ml flask and treat with 50 l of 1N HNO_3 for 30 minutes with periodic haking. Filter the extract through an ashree filter. Then place 20-30 ml of the filtrate a 50-ml heat-resistant flask; add 1.0 ml of 0% H_2O_2, and then slowly evaporate to dryness. reat the filtrate with 0.5 ml of H_2O_2 and 5-10 rops of concentrated HNO_3 once or several imes while evaporating, to oxidize completely he organic material. Dissolve the residue hile heating by adding 5-6 drops of concenrated HNO_3 and 5 ml of distilled water. It is ermissable to add one drop to 30% H_2O_2 and ring the solution to boiling to dissolve the esidue. Add 2-3 drops of a 1N solution of MnO_4 to the hot solution until the liquid turns lightly pink and then add 0.3 g of anhydrous odium citrate, heat, add approximately 0.3-.5 g of anhydrous sodium acetate and heat gain. The reaction of the solution must be bove pH 5.5 (according to universal indicator eper). This is achieved by adding sodium cetate. Then add 0.5-1.5 ml of a 0.1% solution of nitroso-R salt and boil the solution for 0-20 seconds.

Then pour 3 ml of a mixture of phosphoric nd nitric acids (five parts of 85% H_3PO_4 + one art of concentrated HNO_3) into the solution; dd 10-30 ml of distilled water so that there ill be 0.5 ml of the nitroso-R salt per 10 ml f solution. Carry out the comparion with the cale in 16-mm test tubes.

The analysis is computed by the formula:

$$x = \frac{a \times c}{d \times n}\ 5{,}000$$

here x is the Co in mg per kg of soil; a is e quantity of Co in mg in 10 ml of solution hich matches the test tube of corresponding olor in the scale; c is the final volume of e liquid analyzed, in ml; d is the weighed ortion of soil used for the analysis, in g; n the volume of the soil extract used for the nalysis, in ml; and 5,000 is the coefficient to onvert data in mg per kg of soil.

The initial solution for the scale of knowns ontains 1 mg of Co per ml and is prepared by issolving 4.9362 g of $Co(NO_3)_2 \times 6\ H_2O$ in ne liter of distilled water acidified with 5 ml f concentrated HNO_3. The working solution ontains 0.01 mg of Co per ml and is prepared diluting the original solution 100 times.

The series of 16-mm test tubes is filled with the known working solution according to the following scheme:

Test Tube No.	1	2	3	4	5	6	7	8	9	10
Standard working solution added, ml	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9

Pour distilled water into each test tube to bring the volume to 5 ml; then add 0.3 g of sodium citrate, 0.3 g of sodium acetate, and 0.5 ml of a 0.1% solution of nitroso-R salt; heat the liquid and add 3 ml of the acid mixture and then distilled water to bring the volume to 10 ml. The test scale is prepared for the analysis in this manner.

Reagents

1. 1N HNO_3. Dilute 66.2 ml of concentrated HNO_3 (specific gravity 1.41) with distilled water to a volume of 1 liter.

2. 30% H_2O_2.

3. Concentrated HNO_3 (specific gravity 1.41).

4. Sodium acetate.

5. 0.1% solution of nitroso-R salt. Dissolve 0.1 g of nitroso-R salt in 100 ml of distilled water.

6. Phosphoric and nitric acid mixture. Mix five parts of 85% H_3PO_4 by volume with one part of concentrated HNO_3.

7. Sodium citrate.

Molybdenum

Methodology. Available molybdenum is extracted from the soil by an oxalate solution at pH 3.3 and determined colorimetrically by the thiocyanate method. The concentration of oxalates is twice as weak as in the Grieg method. Complete oxidation of the organic material, the formation of an identical degree of acidity of the solutions analyzed, and the reduction of trivalent iron is to be assured.

Analytical Technique. Place 10 g of soil or 5 g of peat into a 100-ml flask; saturate with 50 ml of oxalate solvent; and shake for 30 minutes. Filter the extract; place 20-30 ml of the solution into a 50 ml wide-mouthed, heat-resistant glass flask; add 1 ml of 30% H_2O_2; and then evaporate to dryness. Treat the dry residue in the flask twice with 0.5 ml of H_2O_2 and evaporate to dryness each time. Then add 0.5 ml of concentrated H_2SO_4; heat the solution; add 1 ml of H_2O_2 along the side of the flask; and evaporate the solution until fumes of sulfuric acid appear. Repeat the oxidation with H_2O_2 once or several times until the residue in the flask is completely bleached. After oxidizing, add 5 ml of distilled water and 8 drops of concentrated sulfuric acid; then heat the solution until the residue dissolves.

Pour the solution into a 16-mm test tube with a ground glass stopper, and rinse the flask out with 3-4 ml of distilled water. The total volume of the liquid in the test tube should not exceed 8 ml. Then add 1 ml of 10% KCNS, shake the solution and cool it to approximately 18°C; add 1 ml of 10% $SnCl_2$ and quickly mix. As soon as the reddish color caused by the thiocyanate of trivalent iron completely disappears, add 1-2 ml of isoamyl alcohol and shake the solution gently for 30-60 seconds.[1] After the layers separate, the layer of isoamyl alcohol colored by the molybdenum thiocyanate is compared with the known scale.

The results of the analysis are calculated by the following formula:

$$x = \frac{a \times c}{d \times h}\, 25{,}000$$

where x is the Mo content in mg per kg of soil; a is the Mo (in Mg) in 2 ml of isoamyl alcohol according to the scale; c is the volume of isoamyl alcohol used for the analysis, in ml; d is the weighed portion of soil, in g; h is the volume of soil extract used for the analysis, in ml; and 25,000 is the coefficient to convert the results of the analysis in mg per kg of soil.

The initial solution contains 1 mg of Mo per ml and is prepared from $(NH_4)_2MoO_4$ recrystallized in an ammonia medium by dissolving 2.042 g of the salt in one liter of distilled water. The titration is made more accurate by the conventional method (2). Pour the standard solution containing 0.001 mg of Mo per ml into a series of 16-mm test tubes according to the following scheme to prepare the scale of knowns:

Test Tube No.	1	2	3	4	5	6
Quantity of known solution, ml	0.4	0.8	1.2	1.6	2.0	2.4

Add 8 drops of concentrated HCl into each test tube for each 0.3 ml of concentrated H_2SO_4. Add distilled water to the solution to bring the volume to 8 ml. The quantity of isoamyl alcohol used is 2.2 ml.

Reagents

1. Solvent for the soil extract. Dissolve 12.5 g of ammonium oxalate $(NH_4)_2C_2O_4$ and 6.3 g of oxalic acid $H_2C_2O_4$ in one liter of distilled water; the pH of this solution must be 3.

2. 30% H_2O_2.

3. Concentrated H_2SO_4.

4. Concentrated HCl.

5. 10% KCNS. Dissolve 10 g of KCNS in distilled water and bring the volume of the solution to 100 ml.

6. 10% $SnCl_2$. Dissolve 10 g of $SnCl_2$ in 30 ml of concentrated HCl and bring it to 100 ml with distilled water.

7. Isoamyl alcohol. Keep in a well-closed container in a dark place.

Boron

Methodology. Boron is determined in a water extract by a quinalizarin method. Organic and mineral colloids in the water extract are coagulated with copper sulphate, which later acts as a catalyst during the oxidation of the organic material with hydrogen peroxide. Nitrates interfering with the analy are removed by adding hypophosphites in the presence of HCl and with an excess of H_2SO_4.

Analytical Technique. Place 10 g of soil or 5 g of peat into a 100 ml flask of boron-fre glass No. 29 or LKP; add 0.5 ml of a 3% solution of $CuSO_4$; close the neck of the flask with a funnel and steep in 30 ml of boiling distilled water for 5 minutes. After boiling, shake the liquid again for 5 minutes and filter it. Place 5 ml of the filtrate in a 50 ml flask of the same boron-free glass; add 0.5 ml of 30% hydrogen peroxide; and boil the solution for approximately one minute until the liquid in the flask is colorless; then add 1 drop of 0.5N NaOH.

Heat the flask with all its contents slowly until the liquid evaporates, then add another 0.5 ml of H_2O_2 and evaporate the solution to dryness. During the oxidation process the flask must be heated slowly to avoid loss of boron during the rapid liberation of gases. Treat the dry residue with 4.5 ml of concentrated H_2SO_4 until the salts are completely dissolved. If the liquid has a cinnamon-brow ish hue, it must be heated. Then add 0.4 ml of the reducing agent, potassium hypophosphi in a solution of HCl, and after the formation gas bubbles ceases, add 0.5 ml of a solution quinalizarin in sulfuric acid. Shake the liquid id pour it into a test tube with a ground-glass opper (diameter of the test tube is 16 mm). opper the test tube and leave it for 25 minutes. hen the test tube is compared to the scale of iowns. Run a blank analysis without soil in a milar manner to correct for the boron content the reagents and container.

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[1] The 0.2 ml of isoamyl alcohol added above is a quantity calculated to compensate for the partial solution of the alcohol in a water solution.

If the solution is colored a darker blue than e color of the last test tube in the scale, add 5 ml of the reducing agent, 4.5 ml of conentrated H_2SO_4, and 5.0 ml of quinalizarin to flask and mix it with the contents of the test be. This dilution operation is done one more me if necessary or the analysis is repeated ith a lesser amount of soil extract. It is ecessary to bear in mind that the sulfuric acid sed for the analysis must contain neither oron nor NO_3^-. Use only chemically pure H_2SO_4 r the analysis.

The results of the analysis may be calculated the following formula:

$$x = \frac{(a - a_2) x b}{c x d} 2.727$$

here x is the quantity of B in mg per kg of oil; a is the quantity of B which matches the orresponding test tube in the known scale, mg 11 ml; a_1 is the quantity of B which matches e corresponding test tube of the known scale the blank analysis; c is the weighed portion the soil, in g; b is the final volume of the olution analyzed, in ml; d is the volume of the oil extract used for the analysis, in ml; and 727 is the coefficient to convert the results the analysis in mg per kg of soil.

The initial known solution for the standard cale is prepared from a calculated 1 mg of in 1 ml of solution. This solution is obined by dissolving 2.8578 g of H_3BO_4 in 0.5 of water. Prepare two working solutions om this solution by dilutions — the first with content of 0.01 and the second with a content 0.001 mg of B in 1 ml of solution.

The scale of known solutions is prepared in -mm test tubes according to this scheme:

est Tube No.	1	2	3	4	5	6	7	8	9
	Second solution			First solution					
uantity of known solution, ml	0	0.5	1.0	0.15	0.20	0.25	0.30	0.35	0.40

Add water to the known solution in each test be to bring them to a volume of 1 ml and then d 9.0 ml of concentrated H_2SO_4 and 1 ml of a lution of quinalizarin in sulfuric acid.

Note: Under laboratory conditions it is convenient to use a hot-plate equipped with a rheostat or autotransformer to control the heat used to evaporate or burn off organic material when determining Mn, Mo, Co, and B.

Reagents

1. 3% $CuSO_4$. Dissolve 3 g of $CuSO_4$ in 100 ml of distilled water.

2. 30% H_2O_2.

3. 0.5N NaOH. Dissolve 2 g of NaOH in 100 ml of H_2O.

4. Concentrated H_2SO_4 — chemically pure.

5. Reducing agent. Dissolve 10 g of potassium (calcium, sodium) hypophosphite in distilled water acidified with 5 ml of concentrated HCl. Add distilled water to the solution to bring the volume to 100 ml.

6. Quinalizarin in sulfuric acid. Dissolve 5 mg of quinalizarin in 100 ml of concentrated chemically pure sulfuric acid.

Field Laboratory

To determine microelements under field conditions or in the absence of equipped laboratories, we have designed a field kit — a field laboratory — to determine all six of the foregoing microelements.

All the necessary items for an analysis — vessels, reagents, and celluloid scales for colorimetric analysis — are mounted in the kit — the field laboratory. The dimensions of the kit are 47 x 28 x 15 cm. The weight of the kit together with all its contents is 12 kg. A reserve set of reagents to recharge the kit 20 times and a unit to heat water are included in a separate box. In comparison with existing methods, this analysis is 10 times faster and still retains the usual accuracy.

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METHODS OF DETERMINING THE ACTIVITY OF SOME SOIL ENZYMES

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One of the most important tasks in the field of soil biochemistry and microbiology is the search for new ways and methods permitting a deeper study and understanding of all the manifold biochemical transformations of substances that take place in the soil.

Different investigators have different approaches to the evaluation of the biological activity of the soil. Often biological activity is judged on the basis of results obtained by methods widely used in microbiology for determining the total number of microorganisms and for studying their group composition. These methods permit us to determine the presence in the soil of the different microbiological groups and are quite unsatisfactory for judging the functions of the microorganisms under these or those conditions, or the nature and direction of the biochemical processes taking place in the soil.

Many authors (1, 8, 9, 11, 18) suggest evaluating the biological state of the soil on the basis of the intensity of CO_2 liberation. Most certainly the microbiological factor plays no small role in this process. But it must be remembered that the production of CO_2 in general is a composite process, depending not only on the vital activities of microorganisms but also on the respiration of the roots of plants. Therefore the results of the determination of carbon dioxide evolved cannot provide a real picture of the intensity of the microbiological processes taking place in the soil. According to the correct opinion of Makarov (9) the intensity of the liberation of CO_2 from he soil can be considered only as one of the ndicators of the biological activity of the soil.

Recently the attention of both Soviet and foreign investigators has been attracted to the study of the enzymatic activity of the soil in order to describe its biological state. It is well known that there is a very wide variety of enzymes in the soil; some of them are formed as a result of microbial synthesis, some are synthesized in the plant and enter the soil with secretions of living roots and the remains of dead plants. It is quite reasonable to assume that observations on changes in the activity of various enzymes in the soil will indicate the intensity of transformation of groups of organic compounds. Thus, from the activity of enzymes of the protease and amidase types we can get an idea of the breakdown rate of nitrogen-containing organic compounds. Activity indexes for invertase and amylase, according to this hypothesis, give a picture of the transformation of substances of the carbohydrate type.

Kuprevich in his papers (6, 7) indicated the possibility of using data on enzyme activity in the soil to describe its biological activity. He determined the activity of catalase, invertase, and urease in various soils, and considers the results obtained as an objective indicator of the total biological activity of the soil and relates it directly to soil fertility.

A similar viewpoint is expressed by Hofmann (13, 14, 15, 16, 17), who has devoted a large number of papers to the study of the enzymatic complex of the soil. The enzyme content of the soil, in his opinion, can be used as an index of the intensity of the biological processes taking place therein and accordingly may be considered as an important factor in soil fertility. This conclusion is also reached by Vlasyuk and coworkers (2), Mashtakov (10), and others.

Another group of investigators, while not denying the role of enzymes as sensitive indicators of the biological processes in the soil, do not consider the data on their activity as a criterion of the total biological activity of the soil, and much less as an indicator of its fertility.

In this respect we must mention the work of Scheffer and coworkers (19) as well as those of the Czechoslovakian investigators Drobnik and Seifert (3, 4, 5, 12). After studying the enzymatic activity of forest soils and comparing the data obtained with other indicators for the same soils, Drobnik concluded that there is no parallelism between the activity of any particular enzyme, on the one hand, and the production of CO_2, the number of microorganisms, or ammonification and nitrification, on the other. Using saccharase and amylase as examples, he also showed that there is no direct interdependence between the activity of different enzymes in the same soil.

This agrees completely with the thesis that the activity of any particular enzyme describes only processes related to the transformation of organic substances of a particular sort. According to Drobnik, to obtain a complete characterization of the overall biological state of the soils, these methods must be used in conjunction with others, the most promising of which, in his opinion, is the respirometric method. This method indicates the degree of mineralization of organic substances by the consumption of O_2 (4).

The object of our investigations, the results of which we present in this paper, was to demonstrate, by determining the activity of certain enzymes, the presence of biologically active, easily mobilized forms of organic substance which are usually present in the soil in small quantities. The determination of these substances by chemical means until now has been difficult because of the lack of sensitive methods. This is particularly important in the study of the regime of organic substances under various land uses where the dynamics of these compounds is poorly defined.

Experimental

Objects and methods of the investigation. The soil used in the experiment (conducted during 1957 and 1958) was a sod-podzolic soil from the scientific experiment farm "Snegiri" in Moscow region. The samples were taken at various times during the growing season from separate fields planted with different crops and from several treated small-plot field experiments with the potato (K. V. D'yakonova's experiment, 1957).

The activity of two enzymes was determined: saccharase, connected with the conversion of organic compounds lacking nitrogen, and asparaginase, related to the conversion of mobile nitrogen-containing organic substances. For this purpose we used the method recommended for saccharase by Hofmann and Seegerer (16) and that suggested by Drobnik (12) for asparaginase; we made a few changes in them.

Method of determination of saccharase. Weighed portions of air-dry soil (20 g) were sifted through a sieve with 1-mm opening, placed in a 100 ml flat-bottom flask, and carefully mixed with 2.5 ml of toluol and 10 ml of water. After 15 minutes another 5 ml of wate and 10 ml of a 20% solution of saccharose wer added to the mixture. Then the flasks were stoppered, vigorously shaken, and placed in a thermostat at 37° C.

After 23 hours 75 ml of water, previously warmed to 37° C, were added to them as well as sodium sulfate to accelerate clearing of th liquid; the mixture was shaken and again plac in the thermostat for one hour. After the sol tion cleared, it was filtered through a paper filter and reducing sugars were determined b Bertrand's method. Soil without added saccharose and the substrate alone without soil were used as controls. The activity of the saccharase was expressed as milligrams of invert sugar.

Method of determination of asparaginase. Five grams of air-dry, sieved soil were plac in glass tubes with rubber stoppers or wide test tubes and 1.5 ml of toluol was added to each sample. After 15 minutes 165 mg of asparagine was added in 5 ml of water, and after careful mixing the mixture was incubate at 42° C for 48 hours. After this period had elapsed the action of the enzyme was halfed b adding 1 ml of 50% trichloroacetic acid, and the contents of each tube were transferred wi 10 ml of water to a Conway dish to determine the quantity of ammonia released in the decon position of asparagine. As controls we used tubes with soil but without the substrate and tubes with the substrate (asparagine) but without soil. The activity of the asparaginase was expressed as milligrams of ammonia formed from 165 ml of asparagine.

In addition to the determination of the acti ity of the enzymes in the dried soil samples, we carried out several series of experiments with fresh samples of the same soils. The data obtained were somewhat higher than thos for the activity of the enzymes in the dry samples. This we are inclined to attribute to the presence of small roots; careful removal of the roots from the raw samples is extreme tedious. In addition, as was shown in the papers of Scheffer (19) and Drobnik (3), the process of drying the soil itself tends to redu the activity of the enzymes.

Therefore, having decided in our experiment to determint the enzymatic activity in air-dry soil, in order to obtain comparable results we made these determinations in all cases when the same amount of time had elapsed after taking the samples in the field.

Beforehand a few series of laboratory experiments were carried out on composts, wit the addition of various amounts of organic su stances. The substances used were sacchar nd peptone at rates of 0.025%–0.5% by weight of the soil. The composts were kept at room emperature and periodically moistened. Three replications were made. The activities of the corresponding enzymes (saccharase and sparaginase) were determined by the methods escribed previously.

Figures 1 and 2 show the activity of the nzymes as a function of the concentration of he added organic substances. In the series ith saccharose the activity of the enzyme inreased two or three times even when the substrate was added in an amount of 0.025%. Furher increase in the percentage of saccharose id not cause such a sharp change in the enymatic activity, and at rates above 0.125% ome reduction in activity was observed.

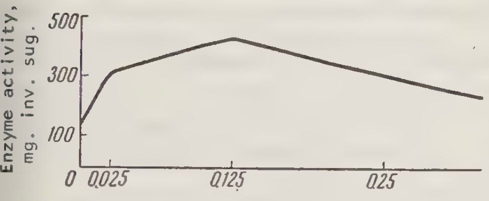

FIG. 1. - Relationship of saccharase activity on concentration of saccharose in composts.

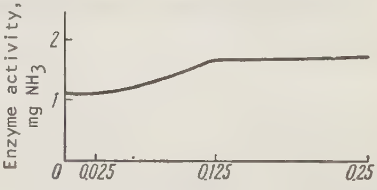

FIG. 2. - Relationship of asparaginase activity on concentration of peptone in composts.

A gradual increase of enzymatic activity ith minute increases in the concentration f substrate was also noted in the experiment ith peptone (Fig. 2).

Thus the data from the laboratory experinents attest the satisfactory response of enymes to the introduction of small amounts of he corresponding organic substances. This erved as our basis for using the method of nzymatic-activity determination for soil amples from various types of land where the mount of the readily mobilized organic subtances is apparently small.

Results of the Investigation

In Table 1 figures are given for the activity f saccharase and asparaginase in soil planted ith potatoes from two variants of the field xperiment.

Treatment I – control – background NPK; reatment II – NPK + 40g humofos (together).

Samples were taken four times during the rowing season: 1 – bud stage; 2 – flowering; – end of flowering; 4 – harvest.

The data in Table 1 show the clear effect of the addition of organic material on the activity of saccharase, while this effect is particular larly marked in the first half of the growing period when, in all probability, there is a rapid release of the mobile forms of organic substances from the humofos. Thus, the values for the activity of saccharase in the treatment with humofos in the first two intervals are twice as high as those in the control. Moreover, these differences smooth out to some extent, but the effect of the humofos is evident until the end of growth.

Confirmation of the fact that saccharase can serve as an indicator of the mobile, biologically active forms of organic substances is found in our further investigations, where, in addition to determining the total content of organic materials, we determined their water-soluble forms. Let us illustrate that with three soils differing in total carbon and nitrogen content (Table 2). From the data of Table 2 we see that during the growing season there remains a direct relation between saccharase activity and the content of organic material, both total and the mobile portion.

Observations on the seasonal change in enzymatic activity for the individual soils shows that relatively small changes in the content of water-soluble organic substances affect the saccharase activity, although the total content of organic carbon remained unchanged to the end of the season.

To obtain a picture of the conversion of nitrogen-containing compounds in the soils studied, as was already mentioned, the activity of asparaginase was determined. Turning to the corresponding data, given in Tables 3 and 4, we note that both in the field experiment with potato and in the soils from the separate fields we observe a tendency for the enzymatic activity to decline as the total nitrogen content in the soil declines. The exceptions (cf. Table 1 – the analyses for July 10-26), in our opinion, can be explained by the formation under the

Table 1

Activity of enzymes in soil planted with potatoes,[a] 1957

Treatment	C	N	July 10, bud stage		July 26, flowering		August 26, end of flowering		Sept. 12, harvest	
	In percent		Saccharase	Asparaginase	Saccharase	Asparaginase	Saccharase	Asparaginase	Saccharase	Asparaginase
NPK + humofos (40g together)	1.04	0.11	30.4	1.85	30.2	1.50	27.0	1.83	25.9	2.02
NPK, control	0.79	0.09	13.9	2.50	15.9	2.45	17.6	0.89	21.1	1.21

[a] Saccharase – mg of invert sugar; asparaginase – mg NH_3.

Table 2

Saccharase activity in various soils in milligrams of inverted sugar, 1958

Soil	C content, %	June 24		August 19	
		Water-soluble organic material, %	Saccharase	Water-soluble organic material, %	Saccharase
Greenhouse soil growing cucumbers	4.41	0.012	38.1	0.02	44.9
Under grass	1.13	0.006	24.4	0.01	28.2
Under sunflowers	0.63	Not det'd.		0.007	18.9

Table 3

Asparaginase activity in various soils, 1958

Soil	N content, %	Enzyme activity, mg NH_3		
		June 24	July 15	August 19
Greenhouse soil growing cucumbers	0.44	11.7	10.2	9.6
Under grass	0.11	0.6	1.0	0.6
Under sunflowers	0.06	Not det'd.		0.2

Table 4

Asparaginase activity in soils under various uses, 1957

Soil	Content, %		Enzyme activity, mg NH_3	
	C	N	Aug. 22	Sep. 12
Growing potatoes (Manured)	1.94	0.18	2.62	2.36
Under grass	1.18	0.12	1.20	1.71
Under oats	0.86	0.10	0.55	1.34

growing plant of readily mobile forms of organic nitrogen, which is also the reason for the increased asparaginase activity.

At the same time the data illustrate the lack of consistent parallelism in the change in activity of saccharase and asparaginase in the soils studied. Thus, in the experiments with potatoes, in the variant with humofos at the end of the growing period, the activity of saccharase dropped off somewhat while that of asparaginase increased. And in the control, on the other hand, a gradual increase in the activity of saccharase toward the end of the growing season was observed; as for asparaginase, its activit after a sharp decline in the second half of August, increased again at harvest time but remained lower than in the first half of the growing season.

The lack of parallelism in the behavior of these two enzymes is also shown convincingly by the data presented in Tables 2 and 3.

All this serves to emphasize the fact that nzymatic activity reflects only individual pro-esses connected with the conversion of particu-ar groups of substances and in no case can it haracterize the total biological activity and uch less the fertility of the soil.

CONCLUSIONS

1. The results of laboratory experiments ith composts indicate the response of the en-ymes saccharase and asparaginase to the ddition of small amounts of suitable, easily obilized organic substances.

2. In work with soil samples taken from and under different usage, the presence of a irect relation between the activity of the en-ymes and the total content of organic sub-tances and nitrogen in the soil was shown. the case of saccharase and asparaginase we bserved a clear tendency for the activity of ese enzymes to decrease as we went from oils with a high content of organic substances soils with a smaller content thereof.

3. Observations on the seasonal changes in e enzymatic activity for individual soils howed the dependence of the activity of sac-harase on the content of water-soluble organic ubstances. This indicates the possibility of accharase activity as an indicator of the pres-nce in the soil of readily mobile, biologically ctive forms of organic substances.

4. The absence of parallelism in the change the activity of saccharase and asparaginase or the individual soils during the growing per-od confirms the hypothesis that the activity of nzymes reflect only processes of conversion definite groups of substances and cannot haracterize the total biological activity for ny particular soil.

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THE EFFECT OF SLOPE EXPOSURE ON SOIL FORMATION N THE REGION OF TEREK-KUMA SAND MASSIFS

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The Terek-Kuma sand massif is a semidesert plain altered by ancient and modern aeolian processes which have formed small-ridged, ridges, large-ridged, and barchan forms of relief. The majority of the ridges run in parallel rows from east to west with slopes facing north and south. Much less frequently the ridges are otherwise oriented, indicating that the local winds also are northwest and west. The ridges and mounds reach heights of 8-12 m or more and are divided by interridge valley-like depressions. Both the ridges and the interridge depressions are composed of fine-grained, light gray or grayish straw-colored sand of uniform texture.

Particle-size analysis of the sand showed that particles 0.5-0.25 and 0.25-0.05 mm in diameter predominate. This means that these massifs should be assigned to the category of readily permeable fine sands. The sand stratum is now very thick. Buried soils are rarely encountered; clay loam layers are not found anywhere, and only in depressions, at depths of one to two meters, do we find layers of carbonate clay loam, locally in the form of individual isolated lenses. The Terek-Kuma massifs differ from the Don and Dnepr sand massifs and resemble those of Astrakhan n the uniform composition of the sand strata as well as in the fine-grain and carbonate characteristics.

The bulk of the sand of the Terek-Kuma massifs is composed of quartz with admixtures of mica and amphibole. The aquifer lies n the sands. The water table, because of the highly dissected relief, varies in depth. In the depressions the water table was found at depths of 2-5 m, but in elevated relief elements (even holes 8 m deep) did not strike it. n all natural springs and holes dug by us the water was fresh, good to the taste, with a total hardness of 8.7-11.7°, and an ion content of 0.23-2.27 mg/l caused chiefly by Ca and Mg bicarbonates (Table 1). Locally in the valley-like depressions we found more highly mineralized ground water. The water in wells reaches a depth of two meters, a fact which indicates a considerable amount of water and the possibility of using it for various purposes.

The high water table in the interridge depressions provides an adequate amount of water in the young soil profile here. Since nutrients are brought down from the more elevated areas, very good conditions for growing plants are created. The interridge depressions have lush meadow grasses and are used like the best hayfields, which are green until autumn.

When the water table is deeper, the depressions, thickly overgrown with vegetation in spring, parch in summer and the soil horizons to a depth of 150 cm are dried out completely. Only at a depth of 150 cm, and sometimes lower, can the soil be called "fresh."

Because of the large difference in moisture and vegetation, the sandy soils on slopes of different exposure are not uniform.

One of the characteristic features of the vegetation of the southern slopes of ridges and mounds of the Terek-Kuma sand massifs is the low number of species. A total of two or three species is found here per m^2, while on the northern slopes they number up to ten. The flora of the northern slopes is enriched by the addition of Kohia prostrata, Agropyrum sibiricum, and Artemisia scoparia, while Astragalus and others are also found.

In addition to the differences found in species, considerable difference is also observed in the structure of the above- and below-ground parts of the plants. One and the same species will grow tall on the northern slope (to 75 cm), and low on the southern. The plants on the northern slopes have heavy root systems, a fact which has an important effect on the temperature and moisture regime of the soils.

The differences in soils are intensified in accordance with the extent to which the slopes and hollows are grown up. Let us consider

Table 1

Chemical composition of soil and ground waters

Ca	Mg	Fe	Na+K	CO_2	HCO_3	Cl	SO_4	NO_2	Solid residue	Total ions	Hardness in degree		
											Total	Removable	Constant
$\frac{0.0364}{4.81}$[a]	$\frac{0.029}{2.38}$	None	0.0034	None	$\frac{0.089}{1.46}$	$\frac{0.061}{1.72}$	$\frac{0.055}{1.14}$	None	0.313	0.2742	$\frac{11.76}{4.20}$	$\frac{4.09}{1.46}$	$\frac{7.67}{2.72}$
$\frac{0.0372}{1.84}$	$\frac{0.0153}{1.26}$	None	0.0066	None	$\frac{0.1201}{1.97}$	$\frac{0.033}{0.93}$	$\frac{0.025}{0.52}$	None	0.283	0.2370	$\frac{8.71}{3.11}$	$\frac{5.47}{1.94}$	$\frac{3.24}{1.16}$

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[a] Numerator — g/l; denominator — meq.

concrete examples of this.

Soils of the large-mound sand massifs. The tops of the high breaks are almost entirely bare of vegetation, while the peripheral parts of the mounds are covered with a luxuriant and succulent grass cover, owing to the abundance of atmospheric and condensation moisture. The soil moisture in the peripheral portion of the mounds remains at almost the same level throughout the year. The tops of the mounds, not being covered with vegetation, are always moist at a depth of 15-20 cm. Their moisture content reaches the value of the full field moisture capacity (12%-15%).

The slopes of the large-ridge and large-mound barchan sands show the initial stages of the soil-forming process: in the upper layer of the sand there are isolated roots.

The soils of different slope exposures differ from one another morphologically. The scanty vegetation, which affords poor protection for the soil, provides wide opportunity for wind action in these areas. The result is the appearance of moving sands, where only solitary individuals of Artemisia arenaria and Calamogrostis epigeios can gain a foothold. Consequently, on the larger topographic elements we do not find marked contrasts in the soils of different slopes. All the slopes of the large-mound and large-ridge plains leave primitive sandy soils that are more like geological than biological (i. e., pedological) formations.

Soils on the slopes of medium ridges and mounds. The soils of the slopes of medium ridges and mounds typically contain a large quantity of roots in the accumulative horizon, some accumulation of humus, especially in the soils of the northern slopes, where the vegetation is thicker and contains Centaurea arenaria, Galium verum, Tragopogon floccosus, and Ephedra vulgaris.

On all slopes the reed Phragmites commun is scattered sparsely and we also find Astragalus virgatus, Euphorbia gerardiana, Elymu giganteus, Calamogrostis epigeios, and other

The plants of the northern slopes have heavily developed root systems and are an important factor affecting the temperature and moisture regimes of the soils.

The soil profile of the northern slopes contains a large quantity of roots roughtly to a depth of 40-50 cm. These gradually diminish lower down, and beyond 70 cm only isolated fine roots are encountered, reaching depths of more than two meters.

During the long dry season soil moisture differs on slopes of different exposure. The soil profile on northern slopes is always dry to a depth of 40 cm and contains only hygroscopic moisture. The layer from 40-70 cm has a moisture content reaching the maximun hygroscopic value. Below 70 cm the soil is even more moist.

In soils that are more humic and thicker, dryness is found to depths of 100-150 cm or more, chiefly on gentle northern slopes as well as in flat areas and interridge depressions that are densely covered with vegetatio This is evidence of the better capillary characteristics of the soils and soil materials on northern slopes and depressions, due to thei high content of particles <0.01 mm in diamete and their accumulation of organic material, and also the higher moisture loss by transpir tion. What we have said is supported by the data given in Table 2.

From the data presented we may conclude that the sandy soils dry out when overgrown

Table 2

Soil moisture on different slopes in percent soil weight

Depth, cm	Slope		Interridge depression	Depth, cm	Slope		Interridge depression
	North	South			North	South	
0—10	0.66	0.60	0.71	80—90	1.80	4.10	0.80
20—30	0.80	1.80	—	100—110	2.50	4.35	0.82
30—40	0.85	2.40	0.75	120—130	3.10	4.80	1.20
60—70	1.40	3.15	—	130—140	3.30	—	3.10

ith vegetation. This drying is stronger, the etter developed the vegetative cover. It is r this reason that the vegetation of soils on outhern slopes is less well developed than on orthern slopes.

Observations on the root systems of plants on outhern slopes have shown that the largest num- er of roots in the soil profile is found at a depth 20 cm. Between 20 and 45 cm the number of oots is small, and at greater depths only single oots can be found.

During snow melting, evaporation from the oil surface on southern slopes is less than on orthern slopes, where the well-developed rass retards snow melting, reduces permeabil- y, and increases evaporation.

During small rains and even with dew (this quite characteristic of the area and usually oundant), the soil on southern slopes also be- omes moister than on northern slopes, where considerable portion of the moisture accumu- tes on the stems of the plants and evaporates sunrise. Observations on September 11, 950, on the soil moisture after a light but rolonged rain showed that the soil was wet on outhern slopes to a depth of 24-25 cm, but to cm on northern slopes.

Medium ridges and mounds are character- ed by poorly developed sandy soils, which e following the steppe line of development. mong the characteristics of these soils are eir pronounced semi-arid steppe climate, e presence of carbonates in the soil profile, eir alkaline reaction, and the nature of the stribution of organic material.

Let us give a description of Profile No. 540- , located in the "9th of January" kolkhoz in elkovskiy district (Checheno-Ingush ASSR), the south slope of a ridge.

A 0-20 cm Light gray, sandy, dry, fri- le, with small content of roots, with numer- s shells of Helix buliminus; violent efferves- nce from HCl. Transition to the following rizon clear.

B 20-45 cm Light gray, dry, friable, small roots of plants not numerous; abundance of the same shells throughout the horizon.

C 45-100 cm and deeper. Uniform sandy carbonate material of grayish color.

On north slopes and also in wind-swept hollows the soils characteristically have a large number of roots, a very thick soil profile, and an accumulative horizon.

The texture of the sandy soils of medium ridges and mounds shows a uniform composition, consisting basically of particles 0.5-0.25 mm and 0.25-0.05 mm in diameter (Table 3). In the upper horizons we find some accumulation of particles <0.01 mm in diameter as a result of plant activities.

In conjunction with some non-uniformity of soil textures on slopes of different exposure, we note a lack of uniformity in the chemical composition. As a result of the high permeability of the soils the mobile salts move to deeper horizons. Analyses of water extracts (Table 4) indicate a somewhat larger content of water-soluble substances in the soils of northern slopes and some increase in them with depth. The carbonate CO_2 content amounts to 1.78% in the upper horizons and increases with depth to 3.14%. This last circumstance must be ascribed to the presence of shells of the mollusk Helix buleminus, which can be found in all profiles. In a number of cases we found enormous accumulations of shells on the surface of the sand and also on the stems of plants. This animal plays a large role in enriching the soil not only in calcium carbonate but also in phosphorus and other elements. Pankov (5) showed that up to 100 kg of lime per acre accumulates from these mollusks.

Soils on plains of small hills. The small-hill plains have mixed tracts of Agropyrum sibiricum and Artemisia campestris, and in places separate areas of Stipa capillata, etc. The northern slopes of small ridges and mounds have a denser vegetation than do the southern slopes.

Table 3

Particle-size analysis of poorly developed sandy soils on slopes of different exposure on medium ridges and mounds, percents

Profile No.	Soil	Slope	Depth, cm	Particle diameter, mm				
				1-0.5	0.5—0.25	0.25—0.05	0.05—0.01	<0.01
40-K	Poorly developed sandy soils on thick sands	South	0—10	None	20.50	70.70	2.50	6.30
			30—40	"	15.90	79.40	1.40	3.30
			70—80	"	16.30	79.30	1.10	3.30
			130—140	"	21.60	75.10	1.20	2.10
41-K	Same	Saddle between mounds	0—10	"	30.50	62.60	1.80	5.10
			30—40	"	13.70	80.00	1.00	5.30
42-KA	Same	North	0—10	"	35.40	53.50	3.30	7.80
			30—40	"	36.10	56.00	2.80	4.50
			70—80	"	37.25	56.35	2.90	3.50
			90—100	"	37.35	59.00	1.50	2.15

The soils consists of widespread sandy and sandy-loam chernozem soils, which have a somewhat unusual profile structure and composition. In the depressions, where the water table lies close to the surface, the soils consist of fairly thick meadow-steppe and meadow chernozemic soils.

The following is a description of Soil Profile No. 587-K, located in a level area on the "9th of January" kolkhoz in Shelkovskiy district, in the central portion of the land under use.

A_1 0-24 cm Gray, sandy, friable, with lizard nests, many roots, dry; vigorous effervescence from HCl. Transitional boundary clear, not level.

A_2 24-56 cm Gray, sandy, friable, fewer roots than in the previous horizon, dry; vigorous effervescence from HCl. Transition gradual.

B_1 56-70 cm Somewhat lighter in color than that above, dry, compact, sandy; effervescence from HCl. Transition gradual.

B_2 70-117 cm Light gray, sandy, dry, a little compacted.

C 117-180 cm Light gray, mellow, sandy, moist; slight effervescence from HCl.

Regarding texture, the sandy soils of the small-hill plains have a relatively high content of particles from 0.05-0.01 mm and <0.01 mm in diameter. In the upper horizons these particles constitute about 10%, and in the soils of northern slopes this value stays almost the same to a depth of 120 cm. In the soils of southern slopes there are fewer clay particles and their concentration decreases gradually with depth. At a depth of 150-160 cm there is practically no physical clay fraction (Table 5).

The sandy soils of the small-hill plains contain more humus than do the soils of the medium-ridge plains, consequently they have a higher thermal capacity and a smaller heat loss (Table 6). On the basis of visual observations, the surface of the soils of the medium-ridge plains cools down slowly. The temperature of the soils and the soil atmosphere remains fairly high until morning.

In the large- and medium-ridge plains the soils on southern slopes, where the vegetation sparse, cool down rapidly. The cold air descends into the interridge depressions, where after sundown the temperature of the soil and the air layer near the ground drops sharply. The microclimatic difference effects a sharp contrast in the plant and soil cover of slopes of varying exposure. Analysis of the sandy soils on slopes of small ridges and mounds have shown that the hydroscopic moisture decreases with depth in proportion to the decline in the content of clay particles and humu (Table 6).

We do not find a large difference in the content of water-soluble compounds as compared with the soils of the medium ridges. We note that there is no clearly removal of solubl salts for the upper horizon of the soil profile. In profile 536-K there are even more chloride in the surface layer than in the one below. Th shows the effect of vegetation and the predomi ance of ascending moisture flow as a result o the pronounced capillarity of these soils. Analysis of the water extracts show a predominance of bicarbonates with a maximum content

Table 4

Chemical composition of poorly developed sandy soils on slopes of different exposure on medium ridges and mounds

Profile No.	Soil	Exposure	Depth, cm	Hygroscopic water %	Humus % (after Tyurin)	CO_2	Water-soluble compounds									
							Dry residue %	CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na	Total ions	pH of water extract
540-K	Poorly developed carbonate sandy soils on thick sands	Southern	0–10	0.60	0.78	1.18	0.063	None	$\frac{0.0308^a}{0.505^a}$	$\frac{0.0052}{0.15}$	$\frac{0.0025}{0.05}$	$\frac{0.010}{0.5}$	$\frac{0.0011}{0.091}$	$\frac{0.0025}{0.11}$	$\frac{0.0522}{1.41}$	7.25
			30—40	0.45	0.50	–	0.0783	"	$\frac{0.037}{0.60}$	$\frac{0.0035}{0.10}$	$\frac{0.0025}{0.05}$	$\frac{0.009}{0.45}$	$\frac{0.001}{0.083}$	$\frac{0.005}{0.21}$	$\frac{0.0581}{1.42}$	7.32
			70—80	—	0.32	2.74	—	—	—	—	—	—	—	—	—	—
			90—100	—	0.23	—	—	—	—	—	—	—	—	—	—	—
542-KA	Same	Northern	0—10	0.70	0.85	1.78	0.072	"	$\frac{0.0431}{0.70}$	$\frac{0.0035}{0.10}$	$\frac{0.0041}{0.085}$	$\frac{0.0111}{0.0555}$	$\frac{0.0025}{0.208}$	$\frac{0.0029}{0.126}$	$\frac{0.0672}{1.27}$	$\frac{7.08}{7.10}$
			25—35	0.24	0.67	—	Not det'd.	"	—	—	—	—	—	—	—	—
			52—62	0.36	0.49	2.15		"	—	—	—	—	—	—	—	—
			90—100	0.98	0.39	3.14	0.088	"	$\frac{0.0493}{0.81}$	$\frac{0.0035}{0.10}$	$\frac{0.0035}{0.073}$	$\frac{0.0162}{0.81}$	$\frac{0.0016}{0.133}$	$\frac{0.0007}{0.030}$	$\frac{0.0748}{1.956}$	—
541-K	Same	Saddle between ridges	0—10	—	0.63	2.87	—	—	—	—	—	—	—	—	—	—
			30—40	—	0.61	—	—	—	—	—	—	—	—	—	—	—

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[a] Numerator — % of soil weight; denominator — meq.

Table 5

Particle-size analysis of sandy soils on different slopes of small-hill plains, percents

Profile No.	Soil	Soil exposure	Depth, cm	Particle diameter, mm				
				1–0.5	0.5–0.25	0.25–0.05	0.05–0.01	<0.01
534-K	Sandy chernozems on thick sands	Southern	0–10	None	31.40	49.50	3.60	10.50
			40–50	"	35.40	51.30	4.20	9.10
			85–95	"	33.40	52.60	6.20	9.80
			110–120	"	31.80	56.90	3.10	8.20
536-K	Same	Northern	0–10	"	44.80	34.70	10.50	10.00
			40–50	"	48.70	35.70	8.30	7.30
			85–95	"	49.60	36.50	7.60	6.30
			150–160	"	51.30	43.60	3.00	2.10

Table 6

Chemical composition of water extract from sandy chernozemic soils of small-hill plains

Profile No.	Soil	Slope exposure	Depth, cm	Hygroscopic moisture	Humus	CO_2	Water-soluble compounds							
				In percents			Dry residue	CO_3	HCO_3	Cl	SO_4	Ca	Mg	Na
534-K	Sandy, carbonate, moderately thick chernozem on sand	Northern	0–10	0.70	1.78	2.13	0.083	None	$\frac{0.0400^a}{0.656^a}$	$\frac{0.0017}{0.050}$	$\frac{0.0074}{0.154}$	$\frac{0.0111}{0.555}$	$\frac{0.0026}{0.21}$	$\frac{0.0002}{0.009}$
			40–50	0.60	1.53	—	0.085	"	$\frac{0.0521}{0.854}$	$\frac{0.0035}{0.10}$	$\frac{0.0035}{0.073}$	$\frac{0.0151}{0.755}$	$\frac{0.0031}{0.26}$	$\frac{0.0005}{0.02}$
			85–95	0.40	0.77	3.60	—	—	—	—	—	—	—	—
			110–120	—	0.66	3.10	—	—	—	—	—	—	—	—
536-K	Sandy, carbonate, thinner chernozem on sand	Southern	0–10	0.60	1.29	1.85	0.075	None	$\frac{0.040}{0.656}$	$\frac{0.0035}{0.10}$	$\frac{0.0051}{0.10}$	$\frac{0.010}{0.50}$	$\frac{0.0024}{0.20}$	$\frac{0.003}{0.25}$
			40–50	0.48	0.51	—	0.083	"	$\frac{0.046}{0.075}$	$\frac{0.0017}{0.05}$	$\frac{0.0041}{0.08}$	$\frac{0.014}{0.07}$	$\frac{0.0019}{0.16}$	$\frac{0.0005}{0.02}$
			85–95	0.42	0.44	2.77	0.069	"	$\frac{0.037}{0.060}$	$\frac{0.0035}{0.10}$	$\frac{0.0035}{0.073}$	$\frac{0.012}{0.60}$	$\frac{0.0017}{0.14}$	$\frac{0.0005}{0.04}$
			150–160	0.40	—	—	—	—	—	—	—	—	—	—

in the layer from 40-50 cm. The absolute values of the alkalinity are 0.04%-0.05%. There are some sulfates, and these are predominantly in the upper horizon.

In the large valley-like depressions with a low water table we find peculiar thick meadow-steppe sandy soils with a humus content in the upper horizon reaching 3%. These soils are dry during the long arid period. In depressions with a high water table under meadow vegetation, thick sandy and sandy loam meadow chernozemic soils are present. These remain uniformly moist all summer because of the available ground water. This ground water is also the basic water reserve for the plants.

Conclusions

1. Sandy soils on slopes of various exposure in the Terek-Kuma sandy massifs have as general characteristics a fine-grained texture, a uniform structure, small amounts of humus, and carbonates, which are often found in considerable quantities even in the upper horizons.

2. Where relief elements are large we do not find sharp contrasts in soils on slopes of different exposure; the difference becomes noticeable where the slopes are heavily sodded and the angle of fall diminishes.

3. The soil formation process on south slopes is noted only when this is clearly the case on the north slope, although both soils need not be the same age.

4. Distinguishing features of the soils on the north slopes and interridge depressions are a pronounced expansion of the soil profile and dryness of the surface horizons overa long period of time.

5. These characteristics of the sandy soils must be taken into account in solving problems of their forest-melioration, improvement, and utilization for agricultural purposes.

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THE COMPOSITION OF HUMUS IN SOD-PODZOLIC SOILS UNDER CULTIVATION

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Improved properties and increased fertility in sod-podzolic soils are primarily a matter of increased humus in the soil. At the same time, the qualitative composition of humus is of considerable importance, particularly the amount and types of the humic acids. In this paper we present the results of a study of the composition of humus in sod-podzolic soils under various degrees of cultivation. These results were obtained in 1956-1957 at the Agricultural Biology Station of Moscow State University at Chashnikova in Moscow Region.

Samples for the study were taken from the plow layer in sod-podzolic silty clay loams as follows: 1) slightly cultivated tract used for field experiments; 2) slightly cultivated soil used in the same experiments, from plots that had been organically fertilized and limed;[1] 3) cultivated soil from a memorial tract; 4) highly cultivated soil from a greenhouse.

All these soils are similar in structure and show signs in their profile of severe podzolization. They have been formed on the same soil of clay loams underlain by a moraine. At the same time, however, they differ markedly from one another in the properties of the plow layer — its fertility, thickness, structure, and chemical composition — and they fall into a series according to degree of cultivation.

The samples of the slightly cultivated soil were taken from a field cleared of forest in 1936. The plow layer of this soil, about 20 cm thick, is dispersed, has a light gray, whitish coloration, and contains about 2% humus and 9-11 mg of mobile aluminum per 100 g of soil. The base saturation ranges from 43%-47%. In the plots with application of organic fertilizers and lime, the base saturation has increased to 78%, and the content of mobile aluminum has decreased to 1.4 mg per 100 g of soil.

The plow layer of the cultivated soil from th manorial tract is darker, blocky in structure, and 22-25 cm thick. The base saturation is 80%-87%, and the humus content, 2.3%-2.6%. There is no mobile aluminum in this soil.

The highly cultivated soil of the greenhouse plot, which has been regularly and heavily manured for many years, has a very thick plow layer (27-30 cm), a dark gray color, an appreciable content of humus (5.47%), and a high base saturation (90%).

Samples of the plow layer of these soils we treated with a 0.1 N solution of NaOH without previous decalcification (2, 3, 6, 8). Determina tions were made of the carbon content of the so-called mobile humic acids and the fulvic acids soluble directly in 0.1 N NaOH, which are present, according to Tyurin (8), partly in the form of compounds with Al', Fe, Ca, and Mg soluble in dilute alkali, and partly in the free state.

At the same time, similar treatment with 0.1 N alkali was given to decalcified samples of the soils being studied, and the content of calcium humates was determined from the difference in the humic-acid contents of the alkaline extracts of the decalcified and nondecalcified soil samples (4, 5).

In Table 1 are the results of the analysis o a single alkaline extract obtained in 1956. The show that during cultivation, particularly whe manure and lime are added, calcium humates accumulate in the plow layer of a soil. In the series of soils studied, the content of calcium humates rose from 2.7% to 12.6% of the total carbon in the soil. Since during cultivation the total carbon content in the soil also increa the absolute content of calcium humates per u weight of soil increases even more — from 0. to 4.27 g per kg of soil. We may mention that the accumulation in the soil of calcium humat

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[1] Lime at full rate according to hydrolytic acidity; manure or peat-liquid compost at a rate of 40 metric tons/ha, applied 3-5 years before the samples were taken for analysis.

Humic acid and fulvic acid content in the humus of sod-podzolic soils under various degrees of cultivation (plow layer).
(Analysis by the Tyurin procedure).

State of soil cultivation	Humus %	Base saturation, %	Mobile aluminum mg/100g	In % of total organic carbon							
				Humic acids		Fulvic acids		Humic acids + fulvic acids		Ratio of humic-acid C to fulvic-acid C	Calcium humates
				1[a]	2[a]	1	2	1	2		
Slightly cultivated	1.94	43.1	11.6	26.0	28.7	31.5	34.6	57.5	63.3	0.83	2.7
Slightly cultivated + manure + lime	1.94	70.8	1.4	22.0	28.7	29.5	30.6	51.5	59.3	0.94	6.8
Cultivated	2.60	82.1	0.0	16.9	26.2	20.5	20.6	37.4	46.8	1.27	9.3
Highly cultivated	5.84	90.0	0.0	10.9	23.5	10.5	11.8	21.4	35.3	2.41	12.6

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[a] 1 — non-decalcified soil; 2 — after decalcification of soil.

with the addition of manure and lime was noted by us earlier also (4).

Together with the accumulation in the plow layer of calcium humates when sod-podzolic soils are cultivated, there is also an increase in the content of mobile humic acids not bound to calcium (in the non-decalcified samples). During cultivation of the soil there was also an increase in the ratio of humic to fulvic acids favoring the humic acids. The ratio of humic-acid C to fulvic-acid C rose from 0.83 to 2.41 in the series of soils studied.

Analyses in 1957 of alkaline extracts from the plow layer of slightly cultivated soils in another experiment and from a moderately cultivated, continuously-plowed soil gave similar results (Table 2). These results showed that, in the course of cultivation of sod-podzolic soils, especially when organic fertilizer and lime are added, there is an increase in the content of calcium humates (from 1.5% to 6.4% of the total carbon), a decrease in the quantity of mobile humic acids not bound to calcium (from 16.7% to 10.1% of the total carbon), and an increase in the ratio of humic-acid C to fulvic-acid C (from 0.64 to 0.75).

In addition to the increased content of calcium humates during cultivation of sod-podzolic soils, there was an increase in the plow layer of the quantity of humic substances not soluble in 0.1 N alkali. This is indicated by the decreased total humic and fulvic acids extracted with 0.1 N alkali. Thus, depending on the degree of cultivation of the soil (Table 1), the total humic and fulvic acids in the plow layer dropped from 63.3% to 35.3%. This indicates an increase in the size of the fraction consisting of humic substances not soluble in 0.1 N alkali from 36.7% to 64.7% of the total carbon. In the soils shown in Table 2, this fraction of humic substances in the decalcified soil samples rose from 51.9% to 60.8% of the total carbon. This fraction of organic substances fails to be extracted from the more highly cultivated soils even with repeated treatment of the soil with alkali after hydrolysis in 1.0 N H_2SO_4. The content of nonhydrolyzing residue in the humus during cultivation of the soils rose from 15.7%-18.3% to 27.8%-33.1% of the total carbon (Table 2).

We note that the humus of cultivated soils (as shown by determinations of its oxidizability made under the supervision of Ye. P. Troitskiy) is more stable to oxidation and more oxidized. In particular, a 0.1 N solution of permanganate under specific conditions oxidized more than 75% of the humus of slightly cultivated soils and only 53% of the humus of a cultivated soil.

In addition to determining the content of the individual fractions in the humus of the plow layer of sod-podzolic soils under various degrees of cultivation, we determined the optical

Table 2

Composition of humus of sod-podzolic soils under various degrees of cultivation (plow layer). (Analysis by the Tyurin procedure)

State of cultivation of the soil, fertilizers	Humus %	Base saturation, %	Mobile aluminum, mg/100g	In % of total organic carbon									
				0.1 N NaOH extract					Carbon in 1.0 N H_2SO_4 hydrolyzate	0.1 N NaOH extract After hydrolysis with 0.1 N H_2SO_4			Insoluble residue
				Humic acids	Fulvic acids	Total	$\frac{\text{humic acids}}{\text{fulvic acids}}$	Calcium humates		Humic acids	Fulvic acids	Total	
Slightly cultivated:													
a) without fertilizer	1.97	47.5	9.2	16.7[a] / 18.2[a]	34.7 / 29.9	51.5 / 48.1	0.64	1.5	13.6 / 13.7	9.7 / 10.3	9.5 / 9.6	19.2 / 19.9	15.7 / 18.3
b) the same + peat-liquid compost with lime 40 metric tons/ha	1.97	82.9	0.2	13.2 / 18.5	25.1 / 24.6	38.2 / 43.1	0.75	5.3	14.9 / 9.4	13.7 / 11.8	12.2 / 11.1	25.9 / 22.9	21.0 / 24.6
c) the same + manure with lime, 40 metric tons/ha	2.33	81.0	0.0	14.0 / 18.5	25.0 / 25.7	39.0 / 44.1	0.72	4.4	15.7 / 12.2	13.8 / 11.3	11.9 / 9.4	25.7 / 20.7	19.6 / 23.0
Moderately cultivated	2.28	87.0	0.0	10.1 / 16.5	24.4 / 22.7	34.5 / 39.2	0.74	6.4	10.6 / 8.5	11.6 / 8.8	15.5 / 10.4	27.1 / 19.2	27.8 / 33.1

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[a] Numerator — non-decalcified soil; denominator — soil after decalcification.

nsity and coagulation threshold of humic acids moved from decalcified and non-decalcified mples of these soils. The determinations owed that the mobile humic acids soluble rectly in 0.1 N NaOH (without decalcification the soil) have a lower optical density and a gher coagulation threshold than humic acids moved from decalcified samples of the same ils and present as calcium humates (Table 3 d Fig. 1). On the basis of the optical density d coagulation threshold (2) we may conclude at the humic acids combined with calcium are ss disperse and more complex in structure an the mobile humic acids not bound to calci- n.

Table 3

Coagulation of humic acid of sod-podzolic soils

State of soil cultivation	Time of observation	Quantity of meq $CaCl_2$ per 1 ltr. of humate when there was observed:			
		Turbidity		Complete coagulation	
		1[a]	2[b]	1	2
Slightly cultivated	After 2 hr	8	6	None	20
	" 24 "	8	4	14	8
Slightly cultivated + manure	After 2 hr	10	6	None	None
+ lime	" 24 "	10	4	"	10
Highly cultivated	After 2 hr	10	6	"	None
	" 24 "	10	6		8

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[a] Humic acid removed from non-decalcified soil.

[b] Humic acid removed from soil after decalcification.

The optical density and coagulation thres- ld of the mobile humic acids in soils under ferent degrees of cultivation vary regularly — e greater the degree of cultivation of a soil, e lower the optical density and the higher e coagulation threshold of the humic acid ction soluble directly in 0.1 N NaOH. Thus, the case of a cultivated manured soil, com- te coagulation of the mobile humic acids es not occur even with a concentration of Cl_2 as high as 20 meq per liter of humate lution, while the mobile humic acid of a ghtly cultivated soil from the control plot agulates completely with 14 meq $CaCl_2$ able 3). Hence, there is reason to believe t in manured cultivated sod-podzolic soils wly formed humic acids accumulate which e highly disperse and less complex in struc- re (1, 2). The presence of this highly dis- rsed fraction of humic acids in heavily field garden soils is also indicated by the fact that, for complete precipitation of the humic acids from alkaline extracts upon acidification of the latter, it is necessary to add an additional amount of H_2SO_4 over and above that called for in the standard procedure.

As was mentioned previously, during cultivation of the soil the formation of calcium humates is accompanied by a decrease in the content of mobile humic acids. Apparently the calcium humates are formed at the expense of the largest and more complex particles of newly formed humic acids, and as a result the mobile fraction retains the more highly disperse particles with a high coagulation threshold and a low optical density. Our attention is drawn to the fact that the humic acids bound to calcium, regardless of the degree of cultivation of the soil, have close optical densities and coagulation thresholds. (Cf. Fig. 1 and Tables 3).

Thus, within the sod-podzolic group of soils, the humic acids bound to calcium show no essential mutual qualitative differences, regardless of differences in the degree of cultivation of the soils.

Conclusions

1. During cultivation of sod-podzolic soils, in particular with the addition of organic fertilizers and lime, calcium humates accumulate in the soil, and the amount of mobile humic acids not bound to exchangeable calcium declines.

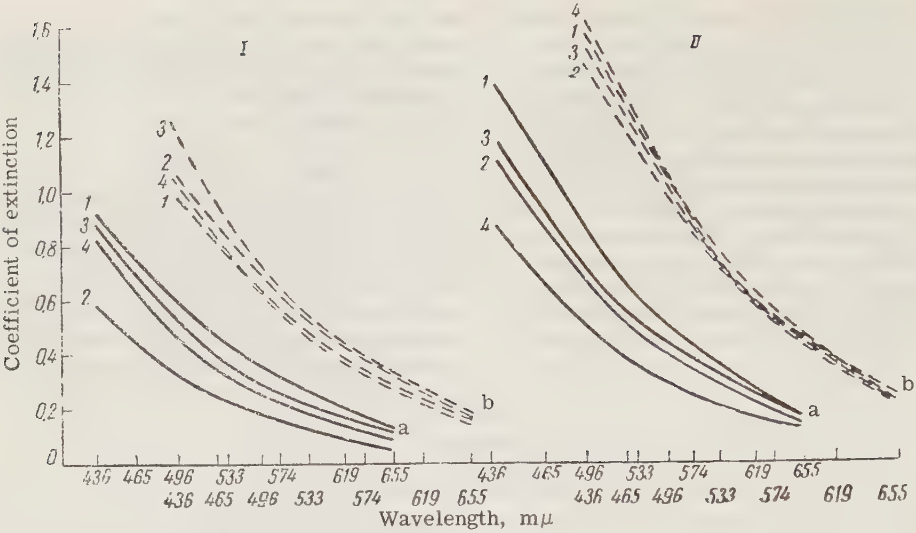

Fig. 1. - Optical density of humic acids of sod-podzolic soils of different degrees of cultivation.

a - humic acids from non-decalcified soils; b - humic acids from decalcified soils. I. 1 - Slightly cultivated soil; 2 - slightly cultivated soil + manure with lime; 3 - moderately cultivated; 4 - highly cultivated. II. 1 - Slightly cultivated; 2 - slightly cultivated + peat-liquid compost with lime; 3 - slightly cultivated + manure with lime; 4 - moderately cultivated.

The ratio of humic acids to fulvic acids changes, at the same time, in the direction of relatively more humic acids.

2. The mobile humic acids not bound to calcium in soils of different degrees of cultivation are less disperse as compared with the humic acids bound to calcium, and they differ from one another markedly in optical density and coagulation threshold. The mobile humic acids of manured, more highly cultivated soils, which include the newly formed humic acids, have a lower optical density and a higher coagulation threshold than the humic acids of slightly cultivated soils.

3. The humic acids bound to calcium are less disperse and have a higher optical density and a lower coagulation threshold than the mobile humic acids. The humic acids of soils differing in degree of cultivation are similar both in optical density and coagulation threshold.

4. The cultivation of sod-podzolic soils is associated with the formation, not only of calcium humates, but also of more stable humic substances that are not removed from the soil with 0.1 N alkali during analysis by I. V. Tyurin's procedure.

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SOLONETZIC SOILS OF THE FRAKIA-DEPRESSION IN BULGARIA

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The Frakia Depression occupies the Maritsa River valley; soils of the cinnamon-brown group have developed (cinnamon-brown forest, cinnamon-brown meadow, etc.) on its terraces. As is well known, these soils characteristically have a profile with a thick compacted horizon (2). When these lands were settled, the forests were cleared, and the ground water began to evaporate from the surface of the ground where it emerged on the terraces of the Maritsa. A new solonetz-solonchak process was superimposed on the previous process of soil formation, and in the Frakia Depression there are presently about 1500 ha of these soils in need of improvement by reclamation. This in turn has raised the question of a more detailed description of the solonetz-solonchak soils of the Frakia Depression. The first studies of these soils were published by Bukoreshliyev (5) and Staykov (7), and later ones by Antipov-Karatayev (1, 2) and others. At present the Soil Institute of the Bulgarian Academy of Sciences is working out reclamation measures for the basic improvement of the lands in question, which are of much economic importance for southern Bulgaria. Accordingly, since 1954 Bulgarian hydrogeologists and soil scientists have been engaged in many types of studies. Special agricultural reclamation experiments have been initiated on experiment station plots. We have studied the initial state of the solonetz and solonchak-like soils on four regional tracts: 1) Radinovo-Kostiyevo; 2) Belozem village; 3) Graf-Ignatiyevo village; and 4) near the city of Plovdiv. Data from these investigations are given in this paper.

The basin of the Maritsa River is bordered by the mountain chains of Sredna Gora, composed of igneous and metamorphic rocks on the left side of the river, and by the Rhodope massifs on the right. The bed of the valley is lined with Pliocene (saliferous) strata, covered above with fairly thick beds of Quaternary deposits, which alternate, as can be seen from the following description of the hydrogeological profile.

Hydrogeological profile No. 134, located near soil profile No. 14 (village of Belozem).

0–0.8 m. Cultivated layer. 0.8–1.9 m. Chestnut clay + 50% small gravel. The water table is located at a depth of 190 cm. 1.9–2. m. Gray-chestnut sandy clay with quartz grains. 2.5–6.0 m. Gray-green clay, compact, sticky, with rust-colored and black patches (impervious to water). 6.0–6.4 m. Blue sandy clay. 6.4–11.2 m. Chestnut sandy clay. 11.2–11.5 m. Small gravel + sand. 11.5–12.0 m. Compact chestnut clay with calcareous concretions. 12.0–13.4 m. Sandy clay, light gray, with red spots and ca careous streaks. 13.4–16.2 m. Light chestnut clay + sand, admixture of gravel. 16.2–18.8 m. Light chestnut compact clay. 18.8–21.2 m. Yellow-green clay, sticky, calcareous concretions. 21.2– 23.7 m. Sandy yello green clay with small gravel. 23.7–27.5 m. Gray-yellow sandy clay with fine dry gravel. 27.5–32.7 m. Gray sandy clay. 32.7–33.5 Light chestnut quartz sand. 33.5–36.5 m. Sandy clay with grains of feldspar. 36.5–38.5 m. Sand + clay with admixtures of fine quartz gravel. 38.5–45.0 m. Gray-green gleyed clay with rust-colored spots. 45.0–48.0 m. Gray clay, sticky, with rust-colore spots.

From the geological structure of profile No. 134, we see that the parent material, co sisting of a fine dispersed sticky clay, is impervious to water.

Figure 1 shows the hydrological profile running north to south along the Maritsa Rive The regime of the ground water is greatly affected by its movement and the texture of the materials through which it travels. Raising of the ground water above its critical lev creates conditions for capillary rise and eva oration from the surface. The critical level the ground water in the region in question is approximately 2–2.5 m.

We shall present data describing the solonetzes in the four regions mentioned above.

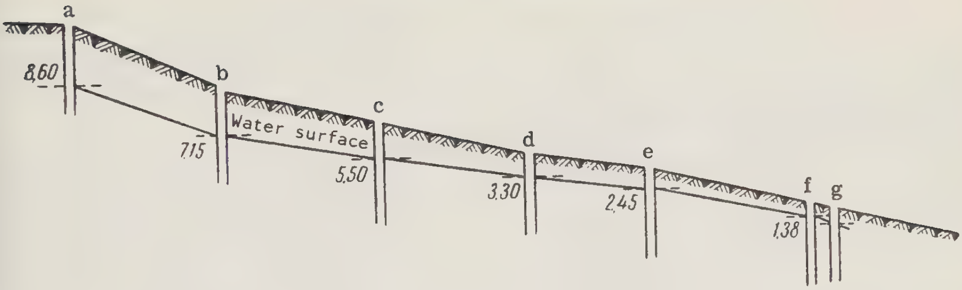

FIG. 1 - Hydrological profile running from Golemo-Konare village on the northern border to Radinovo and Kostiyevo.

Holes: a - 74, north of Golemo-Konare village; b - 70, Kolemo-Konare village; c - 64, between Golemo-Konare and Voysil villages; d - 55, between Golemo-Konare and Voysil villages; e - 45, Voysil; f - 35, Benkovski village; g - 34, Radinovo village.

Radinovo-Kostiyevo District

Profile No. 9. Located 200 m west of Kostiyevo village, in the vicinity of the so-called Mishkov-Gëla.

Virgin soil, characterized by the following natural vegetation: Camphorosma monspeliacum, Atropis convoluta, Trifolium balansae, etc. The soil is a sulfate-solodized deep-columnar solonetz.

0– 5 cm. Light gray, structureless, slightly compacted, whitened by SiO_2; heavy herbage.

5– 25 cm. Dark brown, fine clay loam, compacted, cloddy, heterogeneous, many roots.

25– 55 cm. Darker than the preceding, fine clay loam, highly compacted, prismatic structure, fewer roots.

55– 70 cm. Cinnamon-brown with yellow tinge, clay, structureless, slightly compacted, heterogeneous, precipitated calcium carbonate and oxides of iron, few roots, effervesces.

70–110 cm. Light yellow, clay loam, slightly compacted, heterogeneous, tinged with carbonates, rust-colored ferruginous patches, very few roots.

110–135 cm. Rusty dirty yellow, clay loam, mellow, structureless, non-homogenous, gleyed.

135–170 cm. Light cinnamon, mellow fine-grained, non-homogenous, gleyed, discrete concretions of manganese.

The water table is at a depth of 205 cm (in summer).

Data on the particle-size analysis of Profile No. 9 are given in Table 1.

From Table 1 we see that the clay fraction has accumulated in the layer from 35–45 cm. In this illuvial horizon we also observe the highest content of physical clay (particles <0.01 mm in diameter). The movement of clay particles into the illuvial horizon compacts

Table 1

Particle-size analysis of a sulfate-solod solonetz in percents of dry soil, Profile No. 9

Depth, cm	Particle diameter, mm								Solution losses with HCl treatment
	>1	1—0.25	0.25—0.05	0.05—0.01	0.01—0.005	0.005—0.001	<0.001	<0.01	
0—5	8.47	11.94	14.85	16.93	7.83	8.30	26.72	42.85	4.96
5—25	9.23	9.42	12.84	15.24	6.77	9.92	32.82	49.51	3.76
35—45	8.73	5.52	6.71	11.31	6.06	12.74	40.55	59.35	8.32
45—55	12.80	1.09	44.60	7.94	3.46	6.38	20.84	30.68	2.89
60—70	17.03	1.22	44.14	8.34	3.14	5.73	18.36	27.23	2.04
85—95	10.80	6.63	19.33	17.20	5.47	10.30	13.84	29.61	16.43

Table 2

Content of water-soluble salts in a deep-columnar, sulfate-solod solonetz, Profile No. 9

Depth, cm	pH	Dry residue, %	In meq/100g of dry soil							In % of total meq						
										Anions				Cations		
			$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	$K^+ + Na^+$	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	$K^+ + Na^+$
0—5	8.19	0.455	None	2.790	0.228	2.192	0.270	0.082	4.858	None	53.56	4.38	42.08	5.18	1.56	93.24
5—25	9.25	1.122	0.067	3.850	0.784	7.890	0.574	0.148	11.869	0.54	30.58	6.22	62.66	4.56	1.18	94.26
35—45	9.64	0.996	0.293	4.398	0.679	6.730	0.265	0.115	11.720	2.40	36.34	5.62	55.62	2.58	0.94	96.84
45—55	9.66	0.594	0.630	2.160	0.384	2.334	0.105	0.033	5.370	11.44	39.22	6.96	42.36	1.90	0.60	97.48
60—70	9.62	0.217	0.570	1.618	0.245	0.410	Trace	0.016	2.827	20.04	56.90	8.60	14.44	Trace	0.56	99.42
85—95	9.35	0.067	0.090	0.505	0.062	0.048	0.020	0.016	0.669	12.76	71.62	8.80	6.80	2.84	2.26	94.90
				In meq/l												
Depth of water table, 205 cm	—	0.516g/l	1.070	5.755	0.576	1.206	1.767	1.012	5.828	12.44	66.86	6.70	14.00	20.52	11.76	67.72

Table 3

Content of exchangeable sodium in deep-columnar, sulfate-solod solonetz, Profile No. 9

Depth, cm	Exchangeable cations, meq			Total exch. cations, meq	In % of total, meq		
	Ca^{++}	Mg^{++}	Na^+		Ca^{++}	Mg^{++}	Na^+
0—5	0.44	0.90	5.74	7.08	6.21	12.71	81.07
5—25	0.79	0.90	11.39	13.08	6.04	6.88	87.07
35—45	0.49	1.39	17.65	19.53	2.61	7.12	90.26

greatly and it becomes poorly permeable. able 2 shows the salt composition of this prole. These data also attest the solonetzic haracter of the profile.

The ground water in Profile No. 9 is weakly ineralized – the dry residue amounts to 5 g/l. Sulfate and bicarbonate ions predomate in the chemical composition of the soil nd the ground water. The high content of odium bicarbonate in the profile raises the I considerably. In the profile under conderation sodium predominates throughout e profile, as can be seen from Table 2 odium amounts to 90% of the total cations in illiequivalents).

The data in Table 3 also testify to the olonetzic character of the profile, where odium comprises 80%—90% of the exchange apacity.

This large quantity of exchangeable sodium the adsorption complex of the soil increases e solubility of humus and moves it to the eeper horizons, as is seen clearly in the folwing data.

The humus content in the sulfate-solod deepolumnar solonetz (Profile No. 9) amounts to 65% at a depth of 0–5 cm, 1.10% at 5–25 cm, 80% at 35–45 cm, 0.60% at 60–70 cm, and 60% at a depth of 85–95 cm.

The effect of exchangeable sodium on the olubility of humus is clearly seen in spring nd summer, when there are extended heavy ains. Where water stands it takes on a chestt-red color. The reaction of this tinted ater is strongly alkaline, a fact which indites the presence of soda in the surface horions. This explains the insignificant amount humus in the virgin sulfate-solod solonetzes. e shall not consider the other solonetzes in is region, since in both morphological and emical characteristics they do not differ subantially from the profile considered above Kostiyevo village).

District of Belozem Village

Salinization of the soil in this district is und in approximately 40% of the area within e lands of the workers' cooperative agricultral enterprises (Work Combine). The soil mplex of this district consists of sulfatelod solonetzes, solonchak-like solonetzes, d solonized soils. The relief and microlief of the locality is not uniform and slopes nerally from northwest to southeast in the rection of flow of the Maritsa River. To aracterize the solonetzes of this research te let us give a morphological description Profile No. 14, located 1.5 km east of Belom Village, along the road to the town of Chirpan and Cheren village.

Profile No. 14. Virgin soil. A sulfate-solod medium-columnar solonetz. The vegetation consists of *Hordeum maritimum* (var. *gussonianum*), *Camphorosma monspeliacum*, *Trifolium balansae*, etc.

0– 1 cm. Light gray to white, structureless, friable, whitened by SiO_2 and readily soluble salts.

1– 8 cm. Light gray, clay loam with a high percentage of sand, slightly compacted, structureless, whitened by SiO_2, many roots.

8– 18 cm. Dark gray with cinnamon-brown tint, clay, compacted, poorly defined prismatic structure, many roots.

18– 30 cm. Dark gray, highly compacted, fine clay loams with well-defined structural units in the form of prisms, heterogeneous, many roots.

30– 50 cm. Dark cinnamon-brown, clay loam, compact, heterogeneous, cloddy to prismatic structure poorly defined, roots present.

50– 70 cm. Yellow-brown, clay loam, slightly compacted, heterogeneous as a result of precipitated carbonates and spots of iron hydroxides. Manganese concretions are present, few roots.

70–100 cm. Light yellow, texture tends toward clay loam, heterogeneous, many carbonate inclusions and spots of iron, friable, gypsum crystals encountered.

100–170 cm. Light yellow, rusty, sandy loam, friable, non-homogeneous, tinged with carbonates, streaks of iron hydroxides.

The water table lies at a depth of 2.25 m (in summer).

This profile has a characteristic solonetz horizon at 18–30 cm and is a typical solonetz for the site studied. The particle-size analysis of this soil is given in Table 4.

As can be seen from Table 4, the soil has a large clay fraction (to 40%). The accumulation of this fraction in the illuvial horizon and deeper shows that this profile has been subject to leaching. The solonetzes of this district are distributed in patches among cinnamon-brown meadow soils, which alternate with alluvial meadow soils. They develop as a result of soil-forming processes associated with the periodic rise of mineralized ground water.

Table 4

Particle-size analysis of a sulfate-solod solonetz, Profile No. 14

Depth, cm	Diameter of particles, mm								Solution losses treatment with HCl
	>1	1—0.25	0.25 — —0.05	0.05— —0.01	0.01— —0.005	0.005— —0.001	<0.001	<0.01	
0—8	5.87	9.41	26.77	26.24	5.21	7.60	17.23	30.04	1.67
8—18	4.81	8.49	22.16	18.42	8.89	9.25	25.17	43.31	2.81
18—30	4.15	6.95	22.65	17.94	6.04	9.00	30.90	45.94	2.39
30—50	3.48	5.38	23.13	17.46	3.19	8.75	36.64	48.58	1.97
75—85	3.10	5.93	23.59	15.48	3.22	7.74	38.97	49.93	1.97
110—120	13.69	1.37	28.46	11.64	3.09	2.86	21.37	27.32	17.52
140—170	3.78	1.61	34.39	15.40	3.06	4.60	22.64	30.30	14.52
180—190	14.18	9.55	16.38	14.60	3.30	7.24	26.17	36.71	8.58

The water-soluble compounds in this profile are shown in Table 5, where we see that after the wet spring the summer drought lifts the salts upward. Thus, at a depth of 8 cm the dry residue equals 1.5 g per 100 g of soil. In the dry period the salts do not reach the surface, since the desiccated surface horizon prevents their further rise. The predominant salts in the solonetz profile under consideration are sodium bicarbonate and sodium sulfate, which make up 40%–92% of the solid residue. The high content of exchangeable sodium, up to 35% of the exchange capacity, confirms the characteristic solonetzic nature of the soil. The content and distribution of salt in the profile are similar to the preceding profile, where a considerable amount is found in the deep horizons. The exchangeable sodium and sodium carbonate facilitate the peptization of humus and its leaching to the deeper horizons. The content of humus and carbonates ($CaCO_3$) is shown in Table 6.

District of Graf-Ignatiyevo Village

The solonetzes of Graf-Ignatiyevo Village differ from the preceding in that they show precipitation of salts at the soil surface. The solonetzes and solonchak-like solonetzes of this district are distributed in patches among meadow-cinnamon brown and meadow-bog soils in lower areas, where the water table lies at depths of the order of 90-150 cm but in early spring reaches the soil surface. We give a description of Profile No. 20, which is located on a plain sloping slightly from north to south along the Maritsa River, at Belyy-Geren village to the southeast of Graf-Ignatiyevo village.

Profile No. 20. Virgin soil. Sulfate-solod, solonchak-like, deep-columnar solonetz. Vegetation: Camphorosma monspeliacum, Atropis convoluta, Trifolium balansae, and others.

0– 1 cm. Dark-gray crust of SiO_2, with blue tinge from soluble salts, dispersed.

1– 10 cm. White-gray, heterogeneous, clay loam, peppered with SiO_2, marblized by soluble salts.

10– 25 cm. Brown-gray, heterogeneous, fine clay loam, slightly compacted, manganese concretions encountered, secondary roots present.

25– 65 cm. Gray-dark cinnamon-brown, highly compacted, cloddy to prismatic structure, heterogeneous, carbonate inclusions encountered, small number of manganese inclusions, few roots.

65–100 cm. Yellow-brown, heterogeneous clay loam, slightly compacted, carbonate inclusions and manganese concretions encountered, few roots.

100–140 cm. Dingy yellow, clay loam, structureless and gleyed, carbonate inclusions encountered, isolated roots.

140–155 cm. Light yellow, coarse clay loam, mellow, heterogeneous, layers of sand. Water table at a depth of 1.5 m (in summer).

The analytical data on the salts in the soil profile are presented in Table 7. There we se that this profile is a typical solonchak-like solonetz. The summer droughts, which are accompanied by strong evaporation of moistur from the soil, lift the salts to the surface and concentrate them in the upper horizons. The dry residue at a depth of 0–10 cm amounts to 1.35%, and the salt content drops off in the downward direction. The sodium carbonate content is considerably over the whole profile, especially in the lower horizons, and is apparently the result of biological activity.

Table 5

Content of water-soluble salts in a sulfate-solod solonetz, Profile No. 14

Depth, cm	pH	Dry residue, %	In meq/100 g of absolutely dry soil							In % of total meq						
										Anions				Cations		
			$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	K^++Na^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	K^++Na^+
0— 1	7.60	0.488	0.080	0.484	0.197	5.600	1.003	1.669	3.689	1.24	7.60	3.08	88.04	15.76	26.22	58.00
1— 8	7.56	0.165	0.057	0.595	0.302	1.253	Trace	0.107	2.100	2.38	26.96	13.68	56.76	Trace	4.88	95.14
8— 18	7.30	1.545	0.097	0.385	0.960	18.630	3.334	2.229	14.509	0.48	1.92	4.78	92.80	16.60	11.10	72.28
18— 30	7.20	1.557	0.093	0.414	1.522	18.930	3.145	2.224	15.595	0.44	1.96	7.16	90.40	15.06	10.64	74.30
30— 50	7.11	1.569	0.090	0.443	2.084	19.240	2.955	2.220	16.682	0.40	2.02	9.54	88.01	13.54	10.16	76.32
75— 85	9.18	0.188	0.600	1.202	0.322	0.383	0.180	0.641	1.686	23.94	47.94	13.28	15.28	27.18	25.56	67.24
110—120	8.36	0.073	0.123	0.584	0.130	0.158	0.115	Trace	0.880	12.36	58.70	13.06	15.86	11.54	Trace	88.44
140—170	8.11	0.066	0.103	0.466	0.071	0.127	0.195	"	0.572	13.44	60.76	9.26	16.54	25.42	"	74.58
180—190	8.05	0.052	0.090	0.436	0.096	0.117	0.125	0.230	0.384	12.16	59.00	12.98	15.84	16.92	31.12	51.96
			In meq/l													
Depth of water table 2.25 m	8.45	0.680 g/l	0.470	3.516	1.286	3.700	2.795	2.516	3.661	5.24	38.58	14.34	41.24	31.14	28.04	40.80

Table 6

Content of humus and carbonates in a sulfate-solod solonetz (in percents), Profile No. 14

Nature of determination	Depth, cm					
	0–8	8–18	18–30	30–50	75–85	110–120
Humus	1.57	1.51	1.54	1.55	1.01	0.56
Carbonates ($CaCO_3$)	0.10	0.14	0.13	0.13	5.19	12.36

Table 7

Content of water-soluble salts in a sulfate-solod, solonchak-like solonetz, Profile No. 20

Depth, cm	pH	Dry residue, %	In meq/100g of absolutely dry soil							In % of total meq						
										Anions				Cations		
			$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	K^++Na^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	K^++Na^+
0—1	7.90	1.386	Trace	1.318	0.576	15.010	0.349	0.074	16.481	Trace	7.80	3.40	88.78	2.06	0.44	97.48
1—10	8.00	1.325	0.190	2.475	1.890	12.718	0.270	0.099	16.904	1.10	14.32	10.94	73.62	1.56	0.36	97.86
10—25	8.10	0.865	0.803	2.165	0.874	7.690	0.195	0.123	11.214	6.96	18.78	7.58	66.68	1.70	1.08	97.24
25—65	8.90	0.522	0.330	1.830	0.719	2.402	0.205	0.156	4.920	6.24	34.66	13.62	45.48	3.88	2.96	93.16
65—100	8.76	0.206	0.350	1.569	0.226	0.585	0.135	0.115	2.480	12.84	57.46	8.26	21.42	4.94	2.22	90.84
100—120	8.45	0.174	0.090	1.287	0.282	0.472	0.050	0.132	1.950	4.24	60.36	13.24	22.14	2.34	6.18	91.48
140—160	8.50	0.182	0.217	1.102	0.291	0.535	0.070	0.090	1.986	10.12	51.36	25.56	24.94	3.36	4.20	92.54
			In meq/l													
Depth of water table 1.5 m	8.75	0.933g/l	Trace	5.480	0.942	4.260	3.584	3.002	4.096	Trace	51.30	39.90	39.90	33.56	28.10	38.32

The anions of salt in both the soil and ground water are sulfates and bicarbonates. The ground water contains considerably more calcium and magnesium ions than the soil, but the predominant ion is still sodium. The other analytical data, such as the texture, exchangeable cations, and humus content, also confirm the solonetzic nature of the profile and repeat the principles established for the preceding profiles.

Plovdiv District

Along the right bank of the Maritsa River, southeast and east of the city of Plovdiv, there is another group of salinized soils, which consist of small patches of sodium solonetzes among the meadow-cinnamon-brown and meadow-cinnamon-brown alluvial soils that predominate here.

Let us consider Profile No. 22, which is located 2 km southeast of the city of Plovdiv, in the Aleksandr Stamboliyskiy sovkhoz. The cultivated fields of the sovkhoz are located on a plain with a large number of small depressions. These depressions are occupied by solonetzes and solonetz-like soils.

Profile No. 22. Medium-columnar sodium solonetz. Vegetation: Hordeum maritimum, Trifolium balansae, and other salt-loving plants.

0– 20 cm. Gray with light cinnamon-brown tinge, fine clay loam, friable with a little compaction, effervesces slightly, many roots.

20– 40 cm. Cinnamon-brown-gray, more-pronounced fine clay loam, highly compacted, cloddy to prismatic structure, effervesces slightly, fissures, many roots.

40– 60 cm. Dark cinnamon-brown, clay loam, compacted, moist, poorly defined cloddy to prismatic structure, many roots, effervesces.

60– 90 cm. Yellow-cinnamon-brown, clay loam, sticky, slightly compacted, heterogeneous as a result of various clay tints, many roots.

90–105 cm. Yellow-cinnamon-brown, clay loam, moist, heterogenous as a result of carbonate inclusions and patches of iron hydroxide.

105–130 cm. Rusty yellow, coarse clay loam, friable, heterogenous as a result of carbonates and rusty patches of iron.

130–200 cm. Light rusty cinnamon-brown, coarse clay loam, friable, small amount of carbonates. Water table at 195 cm, capillary rise of water to 100 cm (in summer).

The particle-size analysis of this profile is given in Table 8. Its distinguishing feature is the high percentage of the clay fraction in the layer from 20–60 cm. These results lead us to conclusions similar to those reached on the basis of the data for the preceding profiles, where we also found an accumulation of the fine dispersed fractions in the illuvial horizon and below.

Profile No. 22 also contains a large quantity of exchangeable sodium and sodium carbonate, as is evidenced in the distribution of humus (Table 9).

The chemical composition of Profile No. 22 is given in Table 10. The salts of the profile are chiefly bicarbonates and carbonates of sodium and a small quantity of sulfates and chlorides. In the deep horizons the calcium and magnesium content increases while the dissolved carbonates decline, as can be seen from Table 9.

Table 8

Particle-size analysis of a sodium solonetz in percents, Profile No. 22

Depth, cm	Diameter of particles, mm								Solution losses with HCl treatment
	>1	1–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	<0.001	<0.01	
0–20	2.91	5.16	18.06	26.03	6.31	7.26	26.29	39.86	7.98
20–40	6.27	2.13	22.75	12.15	5.63	11.26	38.63	55.52	7.18
40–60	0.89	1.08	5.60	23.60	7.06	13.33	33.43	54.45	14.36
60–90	0.32	0.63	5.22	30.35	8.81	11.33	28.77	48.71	11.07
90–105	1.91	11.15	26.28	21.98	3.72	5.42	18.46	27.60	10.07
105–130	1.91	7.02	26.92	22.43	2.26	19.82	10.95	34.03	7.68
130–200	1.05	4.85	27.64	24.02	5.92	9.95	19.90	35.77	6.67

Table 9

Content of humus and carbonates in a sodium solonetz in percents, Profile No. 22

Nature of determination	Depth, cm						
	0—20	20—40	40—60	60—90	90—105	105—130	130—200
Humus	2.80	1.63	0.95	0.48	0.29	0.32	0.26
Carbonates ($CaCO_3$)	8.63	7.19	18.00	19.72	16.96	13.63	13.39

Table 10

Content of water-soluble salts in a sodium solonetz, Profile No. 22

Depth, cm	pH	Dry residue, %	In meq/100g of absolutely dry soil							In % of total meq						
										Anions				Cations		
			$CO_3^=$	$HCO_3^=$	Cl^-	$SO_4^=$	Ca^{++}	Mg^+	$K^+ + Na^+$	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$	Ca^{++}	Mg^{++}	$K^+ + Na^+$
0—20	9.29	0.625	0.729	5.075	0.119	1.077	0.334	0.222	6.278	10.66	71.84	1.74	15.76	4.88	3.24	91.86
20—40	9.36	0.484	0.959	3.329	0.646	1.291	0.115	0.115	5.945	15.42	53.40	10.40	20.78	2,50	1.84	95.66
40—60	9.51	0.562	1.199	4.305	0.516	0.981	0.140	0.123	6.773	17.04	61.68	7.34	13.94	1.98	1.74	96.26
60—90	9.05	0.217	0.320	1.910	0.200	0.096	0.070	0.107	2.349	12.66	75.62	7.92	3.80	2.76	4.24	93.00
90—105	8.90	0.098	0.080	0.390	0.811	0.044	0.160	0.148	1.017	6.04	29.44	61.20	3.32	12.08	11.16	76.76
105—130	8.65	0.083	None	0.800	0.121	0.042	0.130	0.230	0.603	None	83.08	12.56	4.36	13,50	23.88	61.62
130—200	8.27	0.086	0.080	0.739	0.121	Trace	0.145	0.222	0.573	8.50	78.62	12,88	Trace	15.42	23.16	60.96
			In meq/l													
Depth of water	7.95	0.826	None	5.340	0.522	0.575	2.231	0.340	3.866	None	82.96	8.10	8.94	34.66	5.28	60.04

Conclusions

. The nature of the salinized soils of the ia Depression is considered. It is shown salinization is taking place in depressed s, being superimposed on a previous stage eadow-bog or cinnamon-brown forest soil ation. The ground water, which flows from west to southeast along the Maritsa River, ally traverses crystalline strata at depths)–15 m and is very slightly mineralized, when it passes the Pliocene deposits, which rich in sodium and other salts, it picks up salts. Later, when it hits the impervious rs, it emerges at the surface of the soil deposits its salts through evaporation.

. Climatically, the Frakia Depression is dry; the precipitation (500–600 mm) is less than the evaporation of soil moisture. refore we find that solonetz processes are acteristic phenomena, occurring locally e result of the action of the ground water e upper soil horizons, since this ground r is mineralized to varying degrees with tes and carbonates.

. The available analytical data)particle- and chemical analyses of the soil) show al solonetzic characteristics. These are n in the high dispersion and high content xchangeable sodium. A characteristic re of these solonetzes is the high content dium bicarbonate and sodium carbonate, h are found in large concentrations even e deep horizons. The high pH results the high content of sodium carbonate, h apparently is produced biochemically.

he present study is preliminary to the lopment of reclamation operations for the Frakia Depression which will be of great importance for the national economy.

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APPLICATION OF THE METHOD OF PHOSPHATASE ACTIVITY DETERMINATION IN AGRICULTURAL CHEMISTRY

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Recently many scientists (4, 6, 11) have attempted to characterize the biological activity of the soil by measuring its enzymatic activity. Although in some cases there is a direct relationship between the vital activities of organisms in the soil and measured enzymatic activity, these instances are observed only under particular conditions. Thus, for example, Mashtakov and his coworkers (5) found that in peat soil the activity of catalase and invertase, the number of microorganisms and the amount of CO_2 liberated is higher than in mineral soil. Vlasyuk and his coworkers (1, 2) found that in the rhizosphere of lupine, clover, buckwheat, and corn, urease is two or three times higher than outside the rhizosphere. The same situation was found in determinations of the activity of catalase, peroxidase, and invertase.

When soils that are similar to one another are compared, in most cases data obtained by different methods are not uniform. For example, Drobnik and Seifert (8) in their studies of forest soils (liberation of CO_2, total number of organisms, nitrification, and ammonification) did not find a correlation between these values. Galstyan (3) found a lower catalase activity in soil samples from fertilized plots than in samples from control plots. Thus, the biological activity of the soil cannot be characterized by data on the activity of soil enzymes only.

Various factors affect the activity of soil enzymes; inorganic and organic soil colloids, root residues, their quality and quantity, and also the supply of nutrien available to organisms which liberate the enzymes. Hayashi and Takijama (10) have shown that where the phosphorous nutrition of the root systems of grain seedlings was deficient, the phosphatase activity was higher than in the case of normal nutrition of the plants. Doby and Feher (7), in experiments with the fungus *Penicilium glaucum*, demonstrated a relationship between the nutrition of this organism and the production of enzymes. This dependence confirms the data of Kramer (12) obtained in studies of soil organisms. The supply of nutrients in soil can be shown by activity determinations of soil enzymes.

We investigated this question by determini the tendency of the soil to break down phenylphosphate. After the manner of Sanders (14) and his coworkers, we used as a substrate di odium phenylphosphate and determined the phenol liberated by enzymatic action. Pheny phosphate for determining phosphatase activi is more suitable than glycerophosphate, sinc the phosphate freed in the determination of th latter is rapidly bound by the soil. But phen is easily determined in the free state (13). I the soil is composted in the presence of easil destroyed carbohydrates (the C:N ratio is reg ulated by the abundance of NH_4NO_3), then afte a few days the activity of the appropriate soil enzymes will also depend on the amount of biologically available phosphorus.

When the soil is composted with phosphor compounds it becomes possible to obtain data the effectiveness of the individual phosphorou compounds by measuring the phosphatase activity.

Method of Investigation

Soil composting. 100 g of air-dry sieved through a 1-mm opening sieve is mixed in a porcelain dish and the nutrients are added in small quantities with constant stirring. The distilled water is added until the whole mass of soil is no longer lumpy. The nutrient mix ture is prepared in the following way: to 100 g of soil is added 1 g of carbon (C) (in the form of 2.37 g of saccharose), 0.05 g of nitr gen (N) (in the form of 0.143 g of NH_4NO_3), and, in the treatment with phosphorus (P), 0.01 g of phosphorus for 0.05 g of nitrogen (N in the form of 0.117 g of NH_4NO_3 and P in the form of 0.0426 g of $(NH_4)_2HPO_4$). After eating the soil in this way it is placed in an rlenmeyer flask, a cotton plug is inserted, d the flask is, placed in a thermostat at a mperature of 21-22°C.

Investigation of enzyme activity. 5 g of the mposted soil are placed in a 150-ml Erlen- eyer flask; 2.5 ml of toluol are added and e flask is shaken for fifteen minutes. Then ml of 0.5% disodium phenolphosphate at pH are added. The mixture is incubated for two urs at a temperature of 37°C, and then 100 of a 0.3% solution of potash alum is added d the mixture is filtered. The phenol in a rtion of the filtrate (2-0.5 ml) is determined the following way. The solution being studied placed in a 25-ml flask to which is added 5 of borate buffer at pH 9.4 and 4 drops of bbs reagent. The mixture is brought up to lume with dstilled water. After thirty min- es the intensity of blue color at a wavelength 660 mμ is determined. The intensity of the lor remains constant for 24 hours. The nit of measurement is from 0.01-0.12 ml of enol (25 ml).

Reagents needed. a. Gibbs reagent. 0.125 g 2,6-dibromoquinonechlorimide are dissolved 10 ml of 96% alcohol. The reagent should stored in a black vessel in the refrigerator, d can be used until the yellow solution begins turn brown.

b. Borate buffer. 28.4 g of $Na_2B_4O_7 \times 10H_2O$ e dissolved in a liter of distilled water and ml of 1 N NaOH are added. The solution s a pH of 9.4.

c. Phenol solution. 1 g of phenol is dis- ved in 1 liter of HCl. The phenol content determined by the Koppeshar method. The ution, if stored in the refrigerator, may be ed for several months.

The phosphates activity is expressed in mg phenol liberated by the action of the enzymes ntained in 5 g of soil.

Results

The results obtained from investigations of l rich in available phosphorus (according to ner-Riem [15], 40 mg P_2O_5 in 100 g of soil) l low in phosphorus (according to Egner- m, 0.60 mg P_2O_5 in 100 g of soil) are given Figures 1 and 2. As shown in Figure 1, en soil is composted for 48 hours, its phos- rous contents apparently supply the require- nts of the multiplying microorganisms for s element. And the phosphatase activity of soil treated with CNS does not differ from t of the same soil treated with CN. Upon ther composting of the samples that did not tain readily soluble phosphorus, the phos- tase activity was higher. This is attributable to the fact that in the latter case the phosphorous nutrition of the soil microorganisms was deficient. We see from Figure 2 that the phosphatase activity of the soil low in available phosphorus shows differences in the various experimental treatments even at the beginning of composting. The reduced phosphatase activity when extra phosphorus is added to this soil, and its high activity in the treatment without phosphorus (with CN) indicate that the microorganisms have an inadequate supply of this important element. The correctness of this conclusion is confirmed by the data on the consumption of sugar during composting of the soil (Figs. 3 and 4). The sugar in the filtrate after incubation of the soil was determined colorimetrically by the method of Dubois (9). The calculations were made for 5 g of soil. The data presented show that the consumption of sugar during composting depends on the supply of phosphorus in the soil. If the supply is adequate, then the phosphorus

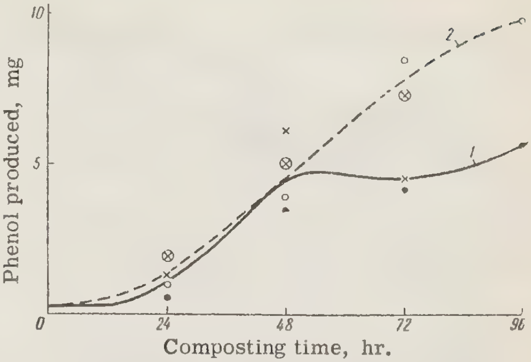

Fig. 1. - Phosphatase activity in soil composted with 40 mg P_2O_5/100 g after Egner.

1 - CNP nutrient mixture; 2 - CN nutrient mixture

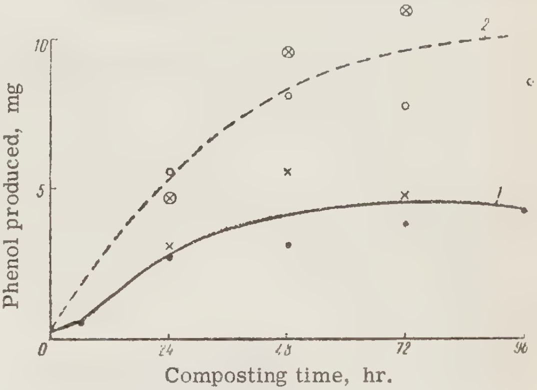

Fig. 2. - Phosphatase activity in soil composted with 0.60 mg P_2O_5/100 g after Egner. (Curves coded as in Figure 1)

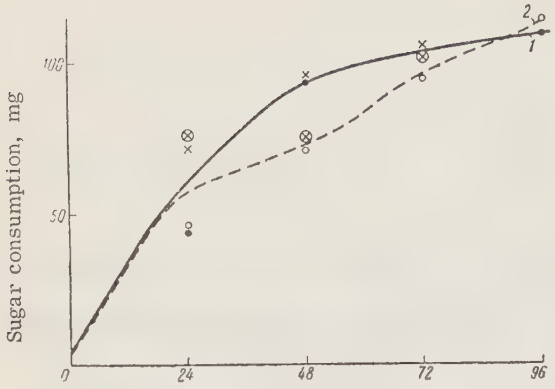

Fig. 3. - Consumption in soil with 40 mg P_2O_5/100 g after Egner. (Curves coded as in Fig. 1)

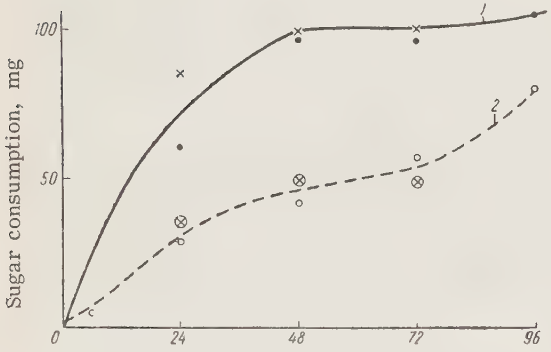

Fig. 4. - Sugar consumption in soil with 0.60 mg P_2O_5/100 g after Egner. (Curves coded as in Fig. 1)

added with the nutrient mixture does not increase the utilization of sugar; but if it is inadequate, then we observe a marked difference in sugar consumption between the treatments without phosphorus and those in which extra amounts have been added. In composted soils, when the microorganisms have an inadequate supply of phosphorus, the phosphatase activity will be higher, and the amount of sugar consumed will be lower than in soil samples low in phosphorus. Thus increased enzymatic activity does not always mean more intense total microbial activity.

The results of the experiment point out a new method of characterizing the state of the soil as regards to phosphorus. They indicate the possibility of diagnosing the biologically utilized phosphorus contents when particular phosphorous compounds are added to a given soil.

Conclusions

Disodiumphenylphosphate is recommende for the study of soil phosphate activity; in tl way the enzyme activity is determined from the amount of phenol produced. When soil i composted in the presence of sugar and ammonium nitrate, we observe an inverse relationship between the enzymatic activity ar the amount of biologically utilized phosphor

The amount of sugar consumed during composting shows that there is no direct relation between phosphatase activity and tota microbial activity.

The results obtained point out new possibilities for diagnosing the state of phosphor compounds in the soil for the purpose of ev ing their biological activity.

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AN AUGER FOR WATER-SATURATED GROUND

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At present the soil auger BP-44 (designation of the Hydrometeorological Service) is used to take soil samples, but this is unsatisfactory in a number of ways. It is difficult to advance the auger in fine-textured clay materials. In these cases the strength of two or more men is required to bore a hole. In addition, it is usually impossible to take soil samples located below the water table (and such samples are important for the study of flood plains), since the water and soil material are not retained by the scoop but flows out of it. Under ordinary conditions the boring interferes with the scooping.

An auger that does not have these drawbacks was designed in 1956-1957 at the Moldavian Scientific Research Institute of Irrigated Agriculture and Vegetable Culture. It is intended for boring holes in water-permeated layers but can also be used for boring in soil of ordinary moisture content (Figs. 1 and 2).

The working parts of the auger (Fig. 2) consist of the bit (4) and the support cylinder (3) with a cutting edge and two longitudinal slots. In working position only the upper part of the first loop is inside the cylinder, closing it. As the boring proceeds the cylinder cuts the hole to size and fills with soil. The diameters of the bit and the cylinder are the same; this makes the boring easier, since the cylinder cuts soil that has already been broken up somewhat by the bit. The walls of the cylinder are 2 mm thick. The cutting edge slants inward for a distance of 4-5 mm. To permit water to escape and to lighten the cylinder, two identical wide (to 1.5 cm), symmetrically located slots are cut in the cylinder.

The bit, which has two or three turns, is welded to a shank and the shank, in turn, is attached to a shaft (1). Below the shaft a collar (6) is welded on the shank together with a sample-ejection ring (5). The external diameter of the collar is equal to that of the shaft. Between the barrel of the shaft and the collar there is a space, somewhat larger than the
thickness of the stop ringe (2). The stop rin
which fits between the support cylinder and t
shaft, holds the support cylinder in position
during boring. To prevent the ring from fall
ing out during operation, it has a small sprin
latch (not shown on the diagram). The suppo
cylinder is slipped over the shaft, and bushin
(7) is slid over collar (6) until stopped by the
ejection ring. Then the stop-ring is insertec
above. During boring the support cylinder
does not turn with the bit, so that friction
against the walls of the hole is less than with
BP-44 auger.

To clear the cylinder to the soil collected
during boring, it is necessary to remove the
stop ring from its channel and raise the cylinder. The soil retained by the ejection
ring remains on the shank and the bit, whenc
it is easily removed. In many cases it happe
that it is difficult to slip the support cylinder
from the sample by hand, and the small leve
shown in Figure 1 (below) is used. The fork
of the level (10) is rested on the support rin
(12) located on the shaft, and the legs (11) a
hooked into the openings in the support cylin
By moving the handle upward the cylinder is
pulled from the sample. The support ring c
be attached to the shaft with screws or three
rings can be welded to the shaft permanently
shown in Figure 1. In the latter case it will
be more difficult to sharpen the support cylinder, since it will no longer be possible to
move it from the shaft for this purpose.

The length of the auger is 1.5 m, but two
shafts of half-inch pipe of the same length c
added ot it. The shaft is assembled as show
Figure 2. A pair of thrust blocks (8) is mo
in the shaft sections to take the torque. Sle
(9), which joins the shaft sections, is not tig
tened during the boring, and the shaft sectio
can be taken apart without exertion. The ha
of the auger and its attachment to the shaft a
as in the BP-44 auger, i. e., there are hole
the sliding handle and the shaft to accept a p

Actual tests have shown that it is easier

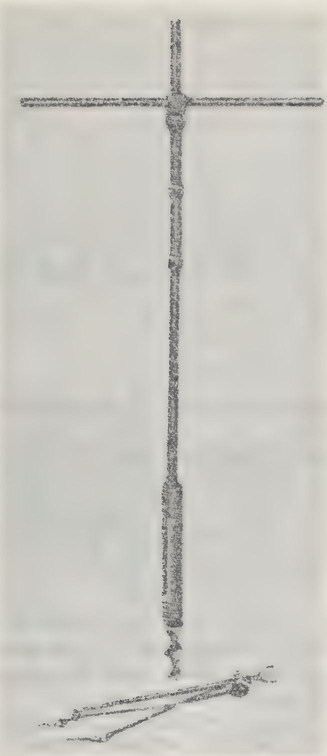

Fig. 1. - General view of the auger. Below is the lever for removing the support cylinder.

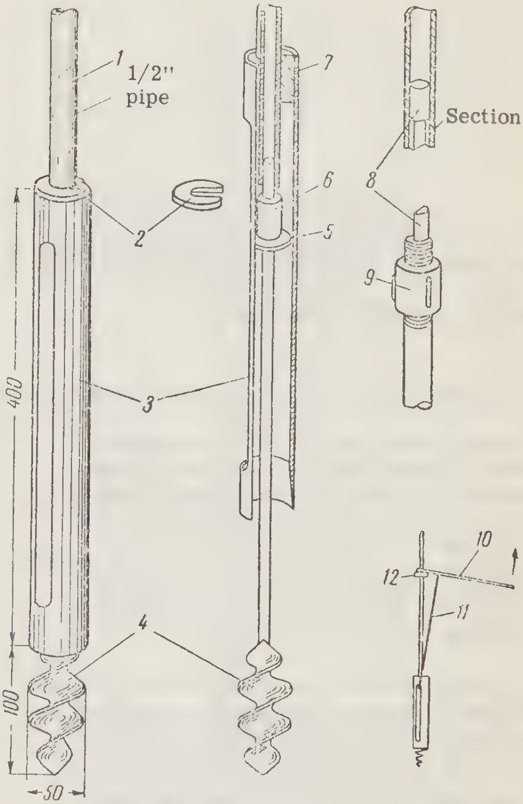

Fig. 2. - Working parts of the auger.

re holes with the auger described than with e BP-44 soil auger, since the bit makes it necessary to push on the handle. Because the removable cylinder, the auger is very ickly emptied of soil.

The support cylinder and the bit form a half-closed chamber, and for this reason the auger can be used to take samples in water-saturated soil. During the boring there is mixing of the ground water in the water-permeated horizon, and consequently this mixing has a certain effect on the composition of the samples taken.

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A DEVICE (PROBE) FOR TAKING SAMPLES OF GROUND WATER AT A GIVEN DEPTH

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Often in the study of the soil and ground water we need to know the degree of mineralization of the ground water at various depths from the water table. It can be particularly important to know the vertical pattern of ground-water mineralization in irrigated areas with land subject to salinization both in connection with leaching salts and recharging the ground water.

In regions where the water table is near the surface, it supplies water to the vegetation, and the concentration of salts in the ground water can be different at different depths. If the upper layer is less salty, then as the total water contents are depleted the roots will receive via the capillaries, water that is more and more salty. In some cases the ground water may be given a high concentration of salts by the irrigation water. The nutrition of plants from the ground water under these conditions may be under these conditions may be unfavorable, and drying of the upper soil layers will cause loss of the plants because of a highly concentrated soil solution. In this case determination of the vertical pattern of ground-water mineralization is useful for practical purposes in choosing the irrigation schedule of the fields or tracts concerned, which may be growing irrigated crops.

Canals from which irrigation water escapes by seepage affect not only the level of the water table but also the degree of ground-water mineralization. The effect of a canal on the level of the water table sometimes extends laterally for several kilometers. But we need to know how far a canal affects the salt content of the ground water at various depths below the water table. This question has been little studied.

One reason for our lack of knowledge about the degree of salinization of ground water at different depths is the difficulty of obtaining vertically distributed samples for analysis.

A device (probe) used in the soil-reclamation laboratory of the All-Union Scientific Research Institute of Hydraulic Engineering a Reclamation (VNIIGiM) and designed by the author of this paper in collaboration with Engineer V. S. Khromov eliminates this deficiency and makes it possible to take vertically distributed water samples.

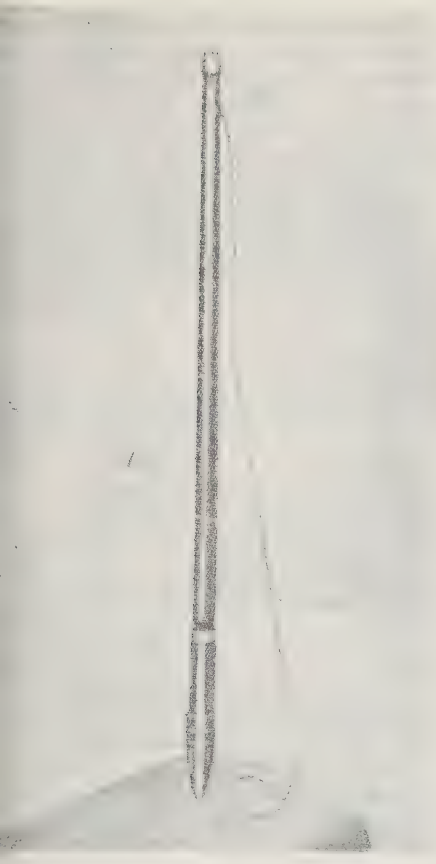
Purpose of the device. The probe is designed for taking samples of ground water fro a given depth with a view to the subsequent determination of their dissolved salts. The size of the samples is about 100 ml. The probe should not be confused with the ordinary bottle sampler, which is used to take samples from different depths in water bodies or boreholes. The probe, in contrast to bottle samplers, permits the taking of water samples directly from the ground at the desired depth below the water table.

Construction of the probe and its operation The probe consists of a head (A), a sectional shaft (B) of the length needed, and a cable (C) running from the head mechanism to the surface of the ground (Fig. 1).

To take a sample it is necessary to bore a hole with an ordinary hand auger to the wate table. Then screw the head of the probe to th shaft and drive the probe into the water-permeated layer of the ground to the desired dept (Fig. 2).

The head of the probe (Fig. 3) consists of a pointed, inwardly sloping endpiece (14), a cylinder (3) with a piston suction pump, and a collecting device — unit (A). The endpiece is used to separate the water-bearing soil as the probe is sunk in the bottom of the hole. Inside the endpiece there is a 100-ml cavity in which the ground-water sample is placed. The endpiece and cylinder are made of stainless steel.

In the lower part of the cylinder is the coll ing assembly (unit A), the external aperture which can be opened or closed with a movable ring encircling the cylinder. The collecting



1. - Device (probe) for taking vertically distributed samples of ground water.

head of probe; B - shaft; C - vacuum-pump cable.

mbly is provided with a screen to prevent of soil material from falling into the water le.

accelerate the flow of ground water into avity, cylinder (3) has in its upper portion tion pump, the piston of which is moved by le running to the surface of the ground gh the tubular shaft (Fig. 2). When the le is being taken the pump is operated by ted pulls on the cable; the pump reduces ressure in the cavity of the probe to 0.5

hen the probe has been lowered into the -bearing ground to the depth, water be- to enter the probe cavity only when the ures of the collecting assembly are open. ccomplish this, the probe on its shaft is d clockwise about 20-30°. When the head probe is turned, it is displaced relative soil, and the ring closing the opening put, since it engages the soil with two

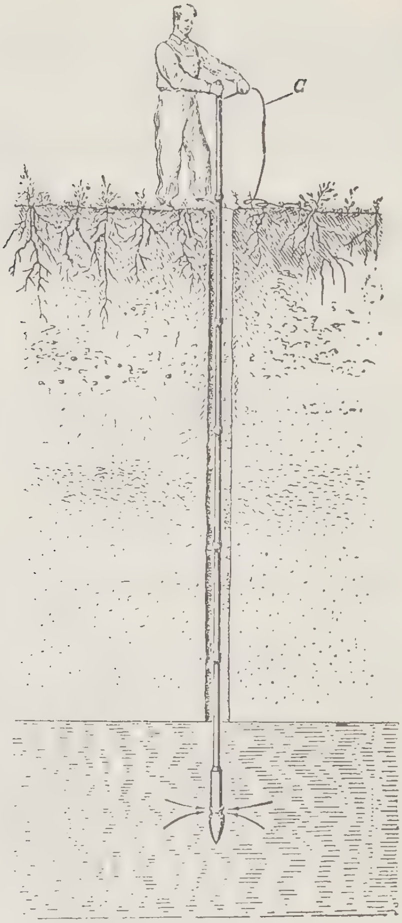


Fig. 2. - Device (probe) for taking vertically distributed samples of ground water to depth of 18 m.

A - head of probe; B - shaft; C - vacuum-pump cable

projecting vanes.

Thereupon, when the aperture of the collecting assembly is open, it is necessary to create a vacuum in the probe by moving the piston and to wait until the chamber in the endpiece is full of water, a fact whichis ascertained from a flashlight-bulb signal. Then the shaft of the probe is turned 20-30° counter-clockwise to close the aperture. To remove the sample, the probe is withdrawn from the hole and the endpiece is unscrewed.

The signal is provided through electrode-shorting by the ground water when it has filled the cavity of the endpiece. One of the electrodes is grounded to the body of the probe; the second is insulated, and a wire from it runs together with the cable to the surface of the ground.

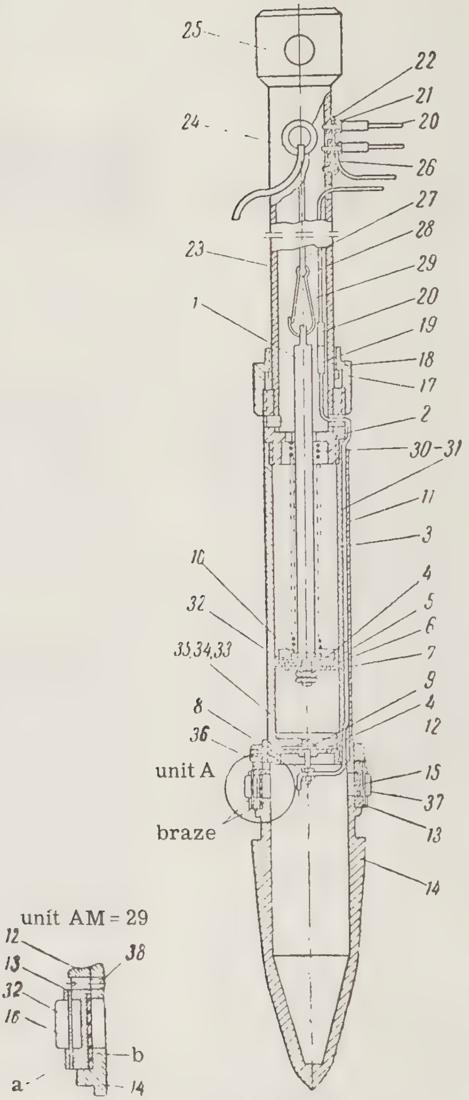


Fig. 3. - Device for taking samples of ground water.

1 - piston; 2 - end plug; 3 - cylinder; 4 - valve washer; 5 - cup washer; 6 - cup; 7 - cup washer; 8 - clip; 9 - valve closure; 10 - washer; 11 - casing; 12 - ring; 13 - shut-off ring; 14 - end-piece; 15 - rubber seal; 16 - ring; 17 - ring; 18 - coupling nut; 19 - electric socket; 20 - electric plug; 21 - socket; 22 - panel; 23 - shaft; 24 - collar; 25 - shaft cap; 26 - M-5 nut; 27 - cable; 28 - wire; 29 - snap hook; 30 - spring; 31 - conductor; 32 - M-5 nut; 3 - M 3x21 bolt; 34 - M-3 nut; 35 - washer 3; 36 M-3 bolt; 37 - screen; 38 - M-3 bolt.

a - screen and ring to be brazed; b - rubber seal to be riveted.

check the filling of the chamber with water, ashlight battery must be connected to the trodes through the wire and the body of probe. For this purpose the wire runs to ocket on a shaft, and the flashlight is proed with a plug. If the next sampling depth nore than 25 cm from the preceding one, after taking the first sample, the hole uld be extended with the auger to a point ut 25-30 cm from the desired sampling h. Then the probe is forced through the om of the hole to the next desired sampling h.

The probe can be used to take samples at siderable depths. During its use in Golod-a Steppe, samples were taken in the depth rval from 2-3 m to 18 m.

In the autumn-winter period of 1958-59 at the Pakhta-Aral sovkhoz (Golodnaya Steppe), studies were made to the vertical distribution of salts in the ground water before and after leaching. This allowed us to establish the presence of appreciable changes in concentration.[1]

By way of illustrating the method, some results of these studies are given in Table 1.

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[1] The studies were made by the Chief Scientist of the soil laboratory of the VNIIGiM, M. V. Preobrazhenskaya.

Table 1

Vertical distribution of salts in ground water on the Pakhta-Aral sovkhoz in 1959-1959. Solid residue, g/l.

Depth, cm	Saline soil				Nonsaline soil	
	Tract number (plots)					
	70		60		68	
	Before leaching Dec. 29-30	After leaching Jan. 4-7	Before leaching Dec. 26	After leaching Jan. 1-4	Before leaching	After leaching Jan. 9-11
1.0—1.3	—	20.0	—	10.5	—	—
2.0—2.2	5.2	15.4	—	4.0	—	3.0
3.0—3.2	5.7	9.9	3.5	3.6	3.0 Aug. 1,'58	2.9
4.0—4.2	—	6.7	—	4.2	3.1 Sept.19,'58	3.8
5.0—5.2	—	5.5	—	4.3	—	3.0
	Depth to water table, meters					
	2.08	0.98	2.3	1.26	3.5	1.7

PHOTOMETRIC DETERMINATION OF BORON BY THE CARMINE METHOD

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For the determination of small amounts of boron in soils and plants the ordinary procedure involves the microvolumetric determination of boric acid by titration in the presence of mannite after Bertrand and Agulon with the modifications of Bobko and Matveyeva (1) and colorimetric determination with quanalizarin or carmine (1, 2).

The volumetric method of boron determination is long and inconvenient for bulk determinations. The colorimetric determination of boron with quinalizarin has the drawback that the procedure involves the use of 98.5% by weight of sulfuric acid, prepared by mixing concentrated sulfuric acid with fuming sulfuric acid (oleum). It is not always easy to obtain chemically pure oleum and quinalizarin of high purity, and in some of our laboratories it is difficult to arrange for purification. Determination by the quinalizarin method can only be visual, since in colorimetry the acidity of the solution often changes and the analysis becomes inaccurate. Use of the carmine method as a visual method with a standard scale is of limited application and reduces the accuracy of the determinations. We have attempted to use the carmine method but with colorimetry and an electrophotocolorimeter. The essence of the carmine method, developed by Kazarinova-Oknina (2) for the determination of boron in borate ores, involves the formation of an intracomplex ester of boric acid with carmine, $C_{22}H_{20}O_{13}$. The solution of carmine in concentrated sulfuric acid assumes a red color, and in the presence of boron the red hue changes to violet-blue.

The photometric determination of boron by the carmine method was studied by Rudin (4), Wiele (5), and Martynchenko and Bondarenko (3). V. D. Rudin worked with a direct-action photocolorimeter with one selenium photoelement. The accuracy of measurement of the direct-action photocolorimeter depends on stability of the light regime of the illuminator, which is very difficult to achieve without a stabilizer. Many agricultural chemistry laboratories use in their work the FED-M-(2) photocolorimeter or the FED-N-57 microcolorimeter-nephelometer with two photoelements. Wo
with these photocolorimeters appreciably i
creases the sensitivity of measurements,
the results are less dependent on fluctuatio
in the intensity of the light in the condense
Photometry with colored reagents, of cour
involves a number of difficulties. In the ca
of the carmine method these difficulties ar
greater, since we have solutions which diff
not in color intensity, but in hue, as a resu
of the superimposition of two colors — that
the reagent (red) and that of the complex t
forms (violet-blue).

In our experiment we investigated a num
of light filters and selected for use as a lig
filter in FED-M-(2) photocolorimetry the
carmine solution itself, and in photocolori
with the FEK-N-57 microcolorimeter-neph
meter, light filter No. 7 or 11. In using t
initial carmine solution as a light filter we
proceeded as follows. The carmine soluti
was poured into individual rectangular cell
with a transmission layer 0.6-1.0 cm thick
cells were interposed between the lamp an
standard or unknown solution. The cells f
the unknown and standard solutions had a t
mission-layer thickness of 2-3 cm. By us
the colored reagent solution itself as a ligh
filter, we tried to increase considerably th
sensitivity of the method studied.

The carmine solution used was a 0.005%
tion in sulfuric acid with a specific gravity
1.82-1.84. For the photocolorimetry, 1 m
a sample or unknown solution containing 0.
$10\mu g$ of boron, 19 ml of the 0.005% carmin
solution were added. In checking the degr
of color change in the solution as a functio
standing time, it was determined that max
color intensity is reached two hours after
tion of the reagent.

Preparation of standard solutions. Sta
solutions were prepared with boron conce
tions of $0.5-10\mu g$ per ml of solution (Table
To prepare the basic solution we took 2.85
recrystallized boric acid and dissolved the

Table 1

Scale of standard solutions

Amount of boron, μg	H_2SO_4 0,5 N	H_2SO_4
	in ml	
0.5	0.95	0.05
1.0	0.90	0.1
2.0	0.80	0.2
4.0	0.60	0.4
6.0	0.40	0.6
8.0	0.20	0.8
10	0.00	1.0

.5 N H_2SO_4 in a 1-liter volumetric flask,
ng to the mark with the same acid solution.
s solution contained 0.5 mg of boron per ml
olution (initial solution). By adding 20 ml
e initial solution to 1 liter of 0.5 N H_2SO_4
btained a working solution containing 10μg
oron per ml. To obtain the exact boric-
concentration in developing the color it is
essary to have 1 ml of the boric acid in
test tube. This is achieved by measuring
standard solution from a microburette and
ing up the volume to 1 ml of 0.5N H_2SO_4
a second microburette.

'o 1 ml of the standard boric acid solution
dd 19 ml of a 0.005% solution of carmine,
e with a stopper, and mix carefully: Two
s later after maximum color intensity has
reached, the mixture is measured with the
trophotocolorimeter. The compensation
t (zero point) is established from water,
e, when concentrated H_2SO_4 is used, it often
es as a result of change in the concentration
e acid.

'o verify the possibility of using the photo-
rimeter we made determinations of boron
oric acid solutions of various concentrations.
The photocolorimeter readings obtained are given in Table 2 and Figure 1. Readings made at different times are close, and the standard-solution curves run parallel to one another.

Determination of boron in plants. Weighed samples (0.5-1.0 g) of pulverized, dry plant material are mixed in a platinum dish or crucible, moistened with a 1% solution of KOH, evaporated on a hot-plate, and slowly ashed in a muffle, reaching temperatures of 500°-550°C. The ashing may be considered finished, when the ash has a pale gray color. The ash obtained is dissolved in 5-10 mm of 0.5 N H_2SO_4 depending on boron content, heated, filtered through an ash-free filter, and 1 ml is taken for determination of boron.

Determination of water-soluble boron in the soil. Weighed portions (50-100 g) of air-dry soil are placed in quartz flasks or flasks of boron-free glass; 100-200 ml of twice-distilled water are added; a reflux condenser is connected; and the mixture is boiled for 5 minutes with constant mixing. After boiling and cooling it is filtered through a folded ash-free filter. A measured volume of filtrate is placed in a quartz dish and evaporated to dryness on a water bath. The dry residue is moistened with a 0.5 N solution of H_2SO_4 containing 2 g/l of hydrazine sulfate (N_2H_4 H_2SO_4) and is carefully ignited until white fumes of SO_3 are given off to destroy oxidizers and organic material. After cooling the residue is dissolved in 5-10 ml of a 0.5 N solution of H_2SO_4, carefully ground with a glass rod, and filtered. One ml of filtrate is removed for the determination. The method was checked on samples of soil and plants from growth experiments; the results obtained were completely satisfactory.

Reagents: 1) 0.5 N solution of sulfuric acid (14 ml H_2SO_4, sp. gr. 1.84, mixed with water to make 1 liter); 2) 0.0005% carmine solution (50 mg of carmine are dissolved in 1 liter H_2SO_4, sp. gr. 1.84); 3) 0.5N H_2SO_4 containing 2 g hydrazine sulfate per liter; 4) twice-distilled water.

On the basis of experimental data, the carmine

Table 2

Reproduction of boron determinations in standard solutions

Micrograms of boron	Photocolorimeter readings							Mean
0.5	0.132	0.132	0.133	0.131	0.131	0.134	0.130	0.132
1.0	0.139	0.139	0.141	0.140	0.140	0.141	0.140	0.140
2.0	0.154	0.155	0.155	0.151	0.152	0.152	0.151	0.153
4.0	0.181	0.182	0.183	0.182	0.175	0.175	0.178	0.179
6.0	0.199	0.199	0.209	0.208	0.190	0.207	0.208	0.204
8.0	0.222	0.228	0.230	0.226	0.226	0.227	0.222	0.226
10	0.233	0.231	0.233	0.243	0.245	0.243	0.243	0.239

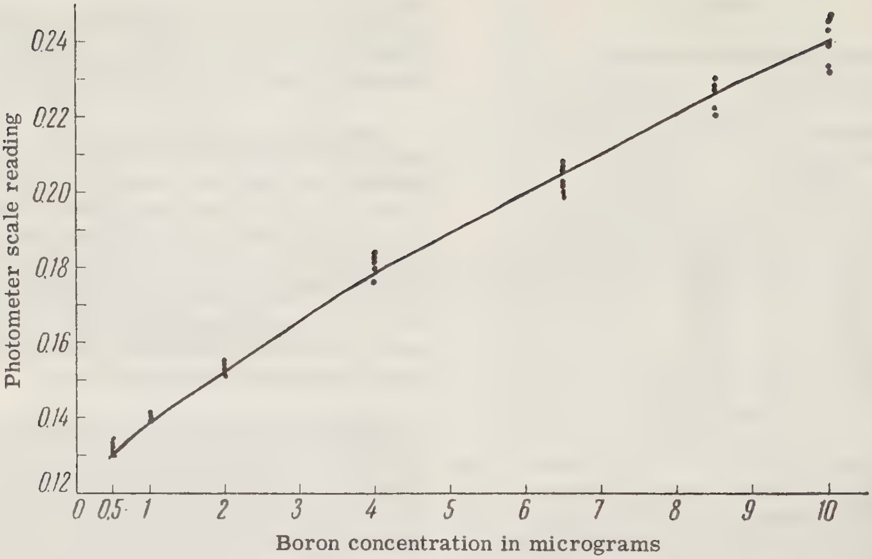

Fig. 1 - Use of the photocolorimeter for the determination of boron.

method coupled with use of the photocolorimeter can be recommended for mass determinations of boron in the soil and plants.

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OMPARATIVE STUDY OF METHODS OF CHEMICAL RE-TREATMENT OF SOILS FOR MECHANICAL NALYSIS BY THE PIPETTE METHOD

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Sciences, Kazakh SSR.

The Kachinskiy method is the one most often
ed in the laboratories of the Soviet Union for
particle-size analysis of soils. Pre-treat-
nt of soil samples for analysis by the Kachin-
y method (3) consists in destroying the car-
nates with hydrochloric acid and displacement
adsorbed Ca and Mg by replacing them with
in the peptization of suspensions with sodium
bonate. The Kachinskiy method gives a
nplete breakdown of the soil into fractions
a high yield of physical clay and clay-like
ticles. For the reasons stated the Kachin-
y method is rightly considered the most ac-
ate method for the particle-size analysis of
ls and is used both in scientific research and
regional soil studies for various purposes.

We should mention that the Kachinskiy
thod is quite tedious; in the course of a
nth the analyst can, by this method, com-
te no more than 60 or 70 analyses.

In the study of soils containing carbonates
gypsum, leaching of the soil with hydro-
oric acid results in high losses. Frequent-
he losses in the treatment of soils with hy-
chloric acid amount to 20% or more of the
ght of the soil. Soviet investigators are de-
oping simpler methods of particle-size an-
sis which can be used in broad, large-scale
studies of a scientific industrial nature.
enevskaya (4) has shown that, in the parti-
-size analysis of podzolic soils, the long
mical pre-treatment used in the Kachinskiy
hod can be replaced by trituration of the
with a pestle to the consistency of a paste.
s method, however, does not achieve com-
e dispersion of suspensions of chernozems
carbonate soils.

To avoid treating them with hydrochloric
d, carbonate soils are treated with various
micals that increase the stability of the
suspensions. Chemical reagents peptize
suspensions more strongly, the more they
ease the charges of the colloidal soil par-
es and bind as relatively insoluble compounds the calcium and magnesium cations displaced from the soil's adsorbing complex.

Preparation of soil materials and soils for particle-size analysis according to Chapovskiy's method (7) involves, first, washing a weighed portion of soil six times with a 0.5 n sodium chloride solution, and then twice with 1N sodium carbonate, followed by washing with water. In this preparation there are appreciable losses of humus. In the study of non-saline soils and non-gypsiferous horizons, pre-treatment by the Chapovskiy method provides fairly complete peptization of the soil suspensions and gives a high yield or physical clay, and clay-like particles. The results obtained are close to results of the Kachinskiy method. In studies of saline soils and especially gypsiferous horizons, very often this method of preparation is a failure — the suspensions flocculate.

The intrinsic deficiencies of this method are: 1. The impossibility of determining the particle-size analysis of the lower horizons of many profiles because of flocculation of the suspension. 2. The tediousness of the method — several washings of the soil sample with the different solutions and water and the determination of the leaching loss for each sample take up a lot of the analyst's time.

Ryzhov (6) has suggested as a dispersing agent sodium oxalate. Pre-treatment for particle-size analysis by Ryzhov's method consists in treating the soil with a solution of sodium oxalate, trituration and boiling of the suspensions, and then ordinarily the suspensions are pipetted. Ryzhov's method is simple and quick, and gives very good results in the study of non-saline soils. The presence even of minute amounts of readily soluble salts in the soil greatly complicates this method, since, by reason of the flocculation of the soil suspensions, the soil cannot be washed before the analysis. Ryzhov's method is widely used in Uzbekistan and the other republics of Central Asia, but lately, because of the drawback mentioned, here also there is a search for a means of replacing it with a more reliable method for studying saline soils (1).

Mel'nikov (5) investigated sodium pyrophosphate as a dispersing agent in the preparation of saline, gypsiferous, and carbonate soil materials for particle-size analysis and found that this compound was better than the other peptizing substances tested by him. Sodium pyrophosphate formed stable suspensions and gave the greatest yield of clay-like particles.

In 1957 the Glavvodkhoz and the Giprovodkhoz prepared the "Instructions for the Particle Size Analysis of Soil Materials by the Rapid Method" (2). Weighed portions of non-saline fine-earths are treated with water, boiled for 40 minutes, then pulverized with the protected finger, placed in a cylinder, and pipetted. Saline and carbonate soil materials are treated with a 4% solution of sodium pyrophosphate at a rate of 1 ml per gram of soil material, triturated with a rubber pestle, and placed in a 1-liter cylinder. 100-ml samples are taken with the pipette and the particle-size analysis of the soil under study is determined from the specific gravity of the suspensions. In this way it was possible to avoid a very long operation — evaporation of the collected samples, which, of course, means a great saving in time and consumption of fuel or electricity. A weak point in this method is the fact that its authors absolutely ignored the evaporation of water in the samples collected, and this is not a matter of slight importance, since in a hot climate it can lead to highly erroneous results.

We set ourselves the task of finding out how effective is the sodium pyrophosphate treatment of carbonate and saline soils in pre-treatment for particle-size analysis. Also to investigate the applicability of this substance for the pre-treatment of non-carbonate and non-saline soils, since in the latter case trituration of the soil paste does not always separate the particles completely.

For our comparative investigation we took samples of saline, carbonate, and non-saline and non-carbonate soils from various districts of the Kazakh SSR. We chose the Kachinskiy method as a standard, with no deviations in the pre-treatment of the soils for analysis.

Soil pre-treatment with sodium pyrophosphate is as follows: a 5-g weighed portion of fine-earths is placed in a No. 3 porcelain dish, 5 ml of a 4% solution of sodium pyrophosphate are added, and the mixture is triturated with a rubber pestle for 15 minutes.[1] The contents of the dish are transferred to a 0.5-liter cylin
and distilled water is added to the mark. A
stirring, samples are tkane with the pipette
as in the Kachinskiy method. The weight of
fraction is corrected for the weight of the s
um pyrophosphate as determined experimen
We adopted this procedure after we were co
vinced that it is impossible to boil the susp
sions in working with sodium pyrophosphate
and that mixing of the soil, paste with a rub
tipped glass rod, as Bratchev (1) recomme
is not suitable, since in this case the yield
physical clay is reduced. Even five minute
trituration with the rubber-gloved finger ga
reduced yield of physical clay. Only tritura
tion with a rubber-tipped pestle, and that fo
no less than 15 minutes, gave good results.
From that point on we adhered to the proce
described previously.

There were cases in which the suspensio
flocculated in our studies of saline soils an
especially in soils containing readily solubl
Ca and Mg salts and large amounts of gypsu
although much more rarely, it is true, than
with the Ryzhov and Chapovskiy methods of
treatments. It was evident to the eye that t
deposited particles of fine sand and silt we
covered above with a fluffy layer of floccula
colloidal particles, which mixed when the c
linder was tilted. A 7.5 ml of a 4% solutio
sodium pyrophosphate was added to the cyli
in which the suspensions had flocculated,[2]
after shaking, samples were taken with the
pipette in the normal manner. In most cas
this was enough to disperse the suspension
complete the analysis. By this means we w
successful in dispersing samples up to 1.5%
salts in the solid residue of the water extra

This procedure is unsuitable only in rar
cases when the suspension flocculates agai
Suspensions of these soils are set aside in
cylinders, and after the soil particles have
settled the clear layer of solution is remov
with a siphon, and the cylinders are again
filled up to volume with a solution containi
25 ml of a 4% solution of sodium pyrosphat
per liter. The suspension is then stirred a
pipetted[3] (Table 1).

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[1] A motor may be used for grinding if the number of turns of the pestle is regulated with a rheostat to 200 rpm.

[2] When a larger amount of sodium pyrophospha
solution is added, correspondingly larger corre
tions must be used for the weight of the < 0.001-
diameter fraction.

[3] Persistently flocculating suspensions we firs
washed with water and then treated again with s
pyrophosphate. Since this procedure is rather t
ous and much time is needed for the suspension
settle before the solution can be decanted, we fi
adopted the expedient of allowing the suspension
settle in a solution of sodium pyrophosphate. S
was much faster in this case and one or two dec
tions were adequate. This procedure is better

Table 1

The effect of boiling on the amount of physical clay in particle-size analysis using sodium pyrophosphate[a]

Sample No.	Profile or hole No.	Depth, cm	Hygroscopic moisture, %	Pre-treatment	Content of fractions in % of absolutely dry weight									Type of soil
					Diameter of separates, mm									
					>3	Sand			Silt			Clay		
						3–1	1–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	<0.001	<0.01	
1772	250	0–10	1.9	With boiling	—	—	23.9	56.3	9.0	3.2	5.1	2.5	10.8	Dark-chestnut sandy loam
				Without boiling	—	—	23.3	53.9	5.9	3.8	6.8	6.3	12.6	
1892	303	0–10	4.1	With boiling	—	—	3.5	44.7	15.1	8.7	18.0	10.0	36.7	Dark-chestnut solonetz, fine clay loam
				Without boiling	—	—	5.5	32.9	15.3	8.2	15.9	22.2	46.3	
1831		50–60	4.1	With boiling	—	—	4.3	40.4	7.1	8.1	22.0	18.10	48.2	
				Without boiling	—	—	4.0	35.5	9.6	7.4	16.1	27.4	50.9	

[a] Analyst, T. P. Turchaninova; soil scientist, V. V. Redkov; Akmolinsk Region.

In Table 1 are given values showing the effect of boiling, in the pre-treatment of soils for particle-size analysis with sodium pyrophosphate, on the amount of physical clay and clay-like particles. We see from this table that it is necessary to refrain from boiling, since this hinders rather than promotes the dispersion of soil suspensions when sodium pyrophosphate is used. The unfavorable effect of boiling on the dispersion of the suspensions in attributable, apparently, to the high solubility of the soil salts in hot water and also to a decrease, during boiling, of the ability of the sodium pyrophosphate to blind the Ca and Mg ions displaced from the soil's adsorbing complex to relatively insoluble compounds[4] (Table 2).

We see from Table 2 that the pyrophosphate method of soil pre-treatment gives the same results with respect to the amount of physical clay as the Kachinskiy method, and consequently this method can be used for soil studies connected with the compilation of maps for scientific-practical purposes, in regional studies for the purpose of land evaluation, in road-siting operations, in regional reclamation surveys, etc. The Kachinskiy scale can be used for classification of the soils.

In the pre-treatment of soil samples by the sodium pyrophsophate method the amount of clay-like particles is slightly less than with the Kachinskiy method, but the amount of fine and medium silt is higher, and therefore the amount of physical clay, as it is called, from the two methods is similar.

This method cannot fully replace the Kachinskiy method. The latter is the basic method for the particle-size analysis of soils and must be used for scientific research of high import, such as, in genetic soil studies, to investigate the movement of clay-like particles under the influence of various natural processes or agricultural practices, and also as a control in the study of typical profiles in all those cases for which we have recommended preparation of the soil by the sodium-pyrophosphate method.

Use of sodium pyrophosphate for the chemical pre-treatment of soils in the modification

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washing the suspensions with water, since calcium carbonate and gypsum are several times less soluble in the sodium pyrophosphate solution than in water. with this type of washing only the readily soluble salts go into solution and are removed, and the relatively insoluble salts do not interfere with the analysis.

[4] We tried to peptize the soil suspensions by triturating the weighed portions with admixtures of solutions of sodium pyrophosphate and sodium carbonate, sodium hydroxide, and sodium oxalate. All these mixtures with and without boiling gave worse results than peptization with sodium pyrophosphate alone.

Table 2

Particle-size analysis of soils[a]

Sample No.	Profile or hole No.	Depth, cm	Percent		Content of fractions in % of absolutely dry weight									CO$_2$, %	Solid residue, %	Type of soil and location of profile
			Hygroscopic moisture	Solution loss	>3	Sand			Silt			Clay				
						3–1	1–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	<0.001	<0.01			
4375	84	0–5	5.0	9.9 K[b]	—	—	—	1.7	31.9	9.8	17.4	29.3	56.5	—	—	Leached, medium-humus chernozem. Eastern Kazakhstan Region. (A. A. Sokolov)
				—P				3.2	38.6	11.7	20.1	26.4	58.2			
4380	—	140–150	3.4	21.3 K		—	—	0.2	30.2	7.0	12.2	29.1	48.3			
				—P				2.9	39.9	11.6	17.0	28.6	57.2			
4872	82	0–9	1.7	4.1 K	—	16.9	2.7	37.2	15.2	5.7	9.2	9.0	23.9	—	—	Mountain-forest, podzolized. Eastern Kazakhstan Region. (A. A. Sokolov)
				—P		16.9	7.9	34.3	17.8	6.4	11.4	5.3	23.1			
4873	"	10–20	2.1	4.7 K	—	16.1	1.5	34.0	18.1	3.4	11.8	10.4	25.6			
				—P		16.1	3.5	28.2	22.6	8.0	13.0	8.6	29.6			
3283	2	0–8	0.8	19.9 K	0.9	4.7	7.6	27.0	16.6	4.7	10.1	9.4	24.2	7.59	0.12	Gray-brown clay loam. Karaganda Region (D. M. Storozhenko)
				—P	0.9	4.7	7.5	32.8	24.9	10.3	15.0	4.8	30.1			
3286	"	28–38	2.8	26.7 K	4.7	7.1	11.2	25.0	5.2	1.0	3.1	20.7	24.8	10.30	0.06	
				—P	4.7	7.1	9.7	30.9	9.3	7.4	18.2	17.4	43.0			
1859	4	60–70	2.4	4.1 K	—	—	—	1.7	40.9	18.7	15.6	19.0	53.3	—	—	Sod-podzolic. Eastern Kazakhstan Region. (G. G. Tsener)
				—P				4.5	41.9	11.2	18.7	23.7	53.6			
1860	"	110–120	3.2	5.2 K				1.7	37.3	11.8	14.4	29.6	55.7			
				—P				2.6	37.7	11.5	16.0	32.2	59.7			
1862	"	220–225	5.2	7.8 K				0.3	38.1	11.6	12.7	29.5	53.8			
				—P				5.4	40.1	8.9	11.9	33.7	54.5			

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[a] Analysts: **M. V. Shilova, Yu. N. Zhdanova, T. G. Turchaninova.**

[b] Kachinskiy pre-treatment — K; Na pyrophosphate pre-treatment — P.

ggested will cut in half the work involved in aking the analysis.

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RAPID DETERMINATION OF NITROGEN, PHOSPHORUS, AND POTASSIUM IN PLANT MATERIAL FROM A SINGLE SAMPLE

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Much attention has been given recently to problems of the diagnosis of the mineral nutrition of plants. One of these methods is the diagnosis of nutrition from an analysis of whole plants or parts of plants for total content of nitrogen, phosphorus, potassium, and other elements. Speed of the determinations is of great importance in the practical use of this method.

The most widely used and precise method of nitrogen determination is the Kjeldahl method. Distillation of ammonia is required in this method, a lengthy operation. Phosphorus and potassium are determined by ashing a separate sample, and this also consumes a considerable amount of time.

A colorimetric method suggests by Shchetinina and Butenko (6) for the determination of nitrogen involves the oxidation of the plant material with sulfuric acid and a $KClO_3$ solution (2). But oxidation of the sample takes a long time and other elements cannot be determined in the same sample.

A. Cavell (7) suggested that sodium sulfate be added instead of potassium sulfate in the oxidation. This made it possible to determine nitrogen, phosphorus, and potassium from one sample. In this method nitrogen is determined by ammonia distillation; phosphorus, colorimetrically; and potassium, with the flame photometer. The drawback of the method is the long time required for oxidation of the sample and determination of nitrogen.

The oxidation may be speeded up by using hydrogen peroxide. A few such methods are known. Troitskiy (4) has suggested using sulfuric acid and 30% hydrogen peroxide to ash the plant material. But this method also involves a cumbersome and lengthy oxidation. Nitrogen is determined by ammonia distillation. Phosphorus and potassium also may be determined in a single sample. Pinevich (3) has developed a method for the rapid oxidation of plant material with hydrogen peroxide. Nitrogen is determined in this method by ammonia distillation. Phosphorus is also determined in the same sample by a colorimetr method.

The most successful method, in our opini for use in diagnosing the nutrition of plants is that of Lindner (8). In this method the plant material is oxidized with sulfuric acid and hydrogen peroxide; nitrogen and phospho are determined colorimetrically; and potassi turbidimetrically (the solution is prepared in colorimetric beaker).

We have made a comparison of two metho of oxidizing plant material; the Lindner meth and the Pinevich method. The oxidation by the latter method was done somewhat differe ly than described by the author (the technique oxidation is described below). Table 1 show that the method of Pinevich is the better met of oxidation.

Our comparative determination of nitroge by oxidation according to the method of Pinevich and subsequent ammonia distillation and direct colorimetric determination gave pract cally the same results (Table 2).

The method of oxidizing plant material su gested by us is based on the method of Pinev Nitrogen, phosphorus, and potassium are de termined in one sample of plant material. N trogen is determined with Nessler's reagent without previous ammonia distillation; phosphorus, by the method of Denige (modification of Truog); and potassium, by flame phot etry or nephelometry with cobalt nitrite, as described below.

Oxidation. A weighed portion of the mate to be analyzed — about 0.2 g — is placed in 100-ml flask. Two ml of chemically pure co centrated sulfuric acid is added, mixed with circular motion so that the mixture will stri less against the walls of the flask, and imme iately 1-2 ml of 30% H_2O_2 are added dropwis Thereupon a violent reaction begins, as a re

Table 1

Comparison of methods of oxidizing plant materials

Plant material	For oxidation of 0.2-g sample					
	Lindner's method			Pinevich method		
	Sulfuric acid, ml	Hydrogen peroxide (no. of additions)	Time, minutes	Sulfuric acid,	Hydrogen peroxide (no. of additions)	Time, minutes
Wheat, spike stage	4	6	36	2	3	23
Corn, dough stage	4	6	36	2	3	23
Soybean, kernel	4	6	44	2	3	26

Table 2

Results of determination of nitrogen by ammonia distillation and colorimetry, plant material oxidized by Pinevich method, %

Material analyzed	Ammonia distillation		Colorimetry	
	Replicates	Average	Replicates	Average
Wheat, flowering stage	1.19 1.19 1.18	1.19	1.18 1.16 1.18	1.17
Corn, kernel	1.85 1.84 1.84	1.84	1.88 1.83 1.82	1.85
Corn, leaf	2.34 2.33 2.40	2.36	2.39 2.32 2.45	2.39

which the sample dissolves completely in e sulfuric acid and the contents of the flask ecome colorless (sometimes faintly colored). he flask is placed on an electric hot-plate, ternit or ordinary but covered with an asbestos creen, and heated until the liquid turns brown d white fumes are evolved. Then the flask removed from the hot-plate, cooled some- hat, and one or two drops of hydrogen per- xide are added (until the liquid is decolorized). he flask is again heated on the hot-plate. If e liquid again turns brown with the evolution white fumes, H_2O_2 is added again. Oxida- on is considered complete when the liquid emains colorless with the evolution of white mes. The flask is cooled, the contents are luted with distilled ammonia-free water, and e liquid is poured into a 100-ml volumetric ask (the flask in which the oxidation was car- ed out is washed a few times with water and is is poured into the volumetric flask). The lumetric flask is filled with water to the ark when the solution is at 20°C and mixed. mples are taken from this flask for deter- ination of nitrogen, phosphorus, and potas- um.

An appropriately larger portion of green plant material can be used for the analyses. The weighed portions are conveniently oxidized in groups of 12-24 samples. Four to six flasks are placed on the hot-plate at one time. Then the time required to oxidize one sample averages 6 minutes.

It must be stressed that the hydrogen peroxide is to be added before the contents of the flask are burned and turn black, otherwise the oxidation will take longer. The oxidation takes longer when hydrogen peroxide of lower concentration is used. If there is nitrate in the material being analyzed, then the heating after the first addition of peroxide must continue for about a minute after the appearance of the white fumes. This facilitates the conversion of the nitrates to ammonia. Again, no more than 3-5 drops of H_2O_2 can be added, since with a large excess in the absence of organic material there will be oxidation of ammonia.

If ammonia is found in the distilled water, this must be removed by adding a small quantity of Na_2CO_3 and boiling.

Determination of nitrogen. 1.0-5.0 m of the solution (depending on the estimated nitrogen content) are poured into a 50-ml volumetric flask. To neutralize the excess sulfuric acid, a volume of 2.5% NaOH is added to this flask equalling the volume of solution taken for nitrogen determination. The contents of the flask are diluted with water to make about 45 ml and shaken, 2 ml of Nessler's reagent are added, water is added to the mark and mixed, and the mixture is tested colorimetrically against a known solution of $(NH_4)_2SO_4$.

If the solution becomes cloudy during preparation for colorimetry, something that happens very rarely, then before the Nessler's reagent is added, 2 ml of a 50% solution of Rochelle salt must be added to the flask. The NaOH solution and the Nessler's reagent are conveniently added from a burette.

The known solution of $(NH_4)_2SO_4$, containing 0.005 mg of N per ml, is prepared by dissolving, in a liter volumetric flask, 1.1816 g of the chemically pure salt in water without ammonia and diluting this solution fifty times. A solution of 10 ml of the known solution is prepared for colorimetry.

Determination of phosphorus. 1.0-5.0 ml of the solution (depending on the estimated phosphorus content) are placed in a 50-ml volumetric flask. To neutralize the excess sulfuric acid, a volume of 2.5% NaOH is added equal to the volume of solution taken for phosphorus determination. The contents of the flask are diluted with water to make about 45 ml, 2 ml of the molybdenum reagent are added, and water is added to the mark. Then three drops of the stannous chloride solution are added, and the mixture is measured colorimetrically after five minutes with a known solution of KH_2PO_4. The colorimetry is not completed earlier than 10-15 minutes after the stannous chloride solution was added.

The hydrogen peroxide used to oxidize the plant material often contains an appreciable amount of phosphorus. When the content is small, a correction may be made for it. When the phosphorus content is large, the peroxide must be purified.

A method for removing P_2O_5 from hydrogen peroxide has been worked out by Shkonde (5). One hundred ml of the hydrogen peroxide to be purified are placed in a 250-ml conical flask, 5 ml of 2% $FeCl_3$ are added to the flask, the contents are shaken vigorously for 5 seconds, 5 g of $CaCO_3$ are added, the contents are again shaken for 5 seconds and the whole contents are quickly placed in a Nutsch filter connected to a flask with suction provided by a water-jet or oil pump (high vacuum). The apparatus is placed in a vessel of water so tha its level reaches half the height of the filter. The concentration of the purified H_2O_2 when filtered with cooling amounts to about 25% (initial concentration, 30%). In one hour 1-2 lite of hydrogen peroxide can be purified.

The purified preparation has a faint yellowish tinge. The hydrogen peroxide collected is stabilized at the time of purification by adding concentrated sulfuric acid at the rate of 5 ml for each liter of purified preparation. The peroxide keeps for a long time in a dark bottle coated inside with paraffin and stored in a cool place.

The SiO_2 content in crop plants does not interfere with the determination of P_2O_5. The reagents for the determination of phosphorus are prepared in accordance with the direction for the Truog modification (1).

Determination of potassium. 1.0-5.0 ml of the solution (depending on the estimated potassium content) are placed in a conical flask 25-50 ml. A drop of methyl red is added and the solutionis neutralized dropwise with a saturated solution of Na_2CO_3. An excess of sodium carbonate is added (two drops) and the solution is boiled vigorously for a minute or two to drive off any ammonia. If the amount solution for determination is small, then a little water must be added before boiling. Th flask is cooled and the excess sodium carbonate is neutralized with a few drops of 5% H_2SO The pH of the solution should be about 6.

The solution is transferred to 10-ml volumetric flask (the flask in which the solution was boiled is rinsed with a few small aliquots of water and the rinse water is poured into th volumetric flask). The total volume of solution in the flask should be about 5 ml. Then 0.5 g of crystalline $NaNO_3$ is added to the flas and the flask is shaken until the salt dissolves Then 4 ml of 95% ethyl alcohol is added with stirring, the flask is shaken, and 0.5 ml of a 35% solution of $Na_3Co(NO_2)_6$ is added to the clear solution. The flask is filled to the mar with water, the solution is mixed, and after 1 minutes the solution is observed in the nephel meter with a known solution of K_2SO_4.

The accuracy of the determination depends on careful adherence to the procedure. If the room temperature is below 20-22°C, cloudin from precipitation of salts may appear when the alcohol is added. The sodium cobalt nitrate solution must be added only to a clear solution. At higher temperatures the cloudy potassium cobalt nitrate may not go to compl tion.

The nephelometer should be read only afte all bubbles are gone from the solution. Care should be taken that there are no bubbles on e prisms.

Lindner (8) recommends making the deter- ination turbidimetrically, by observation in e colorimeter with a red filter. In such a etermination, where the concentration of potas- ium in the solution is low, the results obtained re too high. The most suitable concentration r potassium determination is 0.05-0.15 mg $_2$O in 10 ml of the solution prepared for nephel- metry. The analyses are made in two repli- ations. Four samples may be analyzed simul- neously.

The known solution of K_2SO_4, containing 0.05 g K_2O per liter, is prepared by dissolving .8500 g of the salt in a one-liter volumetric ask. A 25 ml of this concentrated solution poured into a 500-ml volumetric flask, water d 10 ml of 1.84-sp. gr. H_2SO_4 are added to e mark. For nephelometry 1-2 ml of this olution is neutralized with sodium carbonate a 10-ml volumetric flask to about pH 6, out 5 ml of water are added and 0.5 g of aNO_3. The rest of the preparation is the ame as for the solution being tested.

Conclusions

1. The quickest of all known methods of xidizing plant material is oxidation with hy- rogen peroxide by the method of V. V. Pine- ch.

2. A method for the rapid oxidation of plant aterial has been worked out based on the ethod of Pinevich. Nitrogen, phosphorus, d potassium are determined in the same ample. Nitrogen is determined colorimetri- lly using Nessler's reagent. Phosphorus is etermined by the method of Denige (Truog odification). Potassium is determined by flame photometry or by a method using cobalt nitrite nephelometry.

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REVIEW

PRINCIPLES OF SOIL REGIONALIZATION FOR AGRICULTURAL DEVELOPMENT

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The September 1958 issue of the Chinese magazine "Soil Science Journal" (Acta Pedologica Sinica), contained a very interesting and useful article by Ma Yun-chin and Wen Chen-wan pertaining to the problems of soil regionalization and summarizing work that has been done in China so far.[1] The article consists of the following three sections: 1) presentation of problems of soil regionalization and of data on which it has been based; 2) consideration of its principles and taxonomic system; 3) description of soil-bioclimatic regions, zones, and mountain soil provinces of China as they appear on the attached diagram of the soil regions.

Since it would be difficult to consider in a short review all the material presented in this excellent article, summarizing 30 years of the development of soil science in China, we shall dwell only on its main points.

The authors use a broad scientific approach to problems of soil regionalization and consider them in conjunction with other types of natural division and China's agricultural problems. According to them, the objective of the soil regionalization is to summarize all accumulated soil data on the basis of "higher theory" for the purpose of "thorough planning and rational distribution of agricultural production." They point out that a plan for the development of agriculture, while being based on economic factors, must be related to the natural and soil conditions in order to take full advantage of "hidden land resources and to assure an increase in agricultural productivity. Thus, in their opinion, the soil regionalization should be "a component part of the state agricultural plan."

While discussing theoretical problems of soil regionalization, the authors emphasize the close connection of agricultural-soil regionalization with soil classification.

The work on soil regionalization of China began in the 1930's, and was chiefly concern with the study of soil combinations and complexes. According to the author's an import new phase of studying the soils began during recent years in the light of "Soviet theory of genesis and zonality of soils" which provided better understanding of a number of general characteristics of China's soils and of their economic significance.

The all-China soil regions, presented by the authors, are based on soil-bioclimatic fa tors, soil zonality, regional soil characteristics, and agricultural characteristics.

The taxonomic system, which they emplo has the following seven subdivisions: soil-bi climatic territory (rank 0), soil-bioclimatic region (rank 1), soil zone or sub-zone (rank soil province (rank 3), soil sub-province (ra 4), soil district (rank 5), soil massive (rank The first two subdivisions are determined pr marily by soil-bioclimatic factors, while the rest of them are, in addition, concerned wit litho-geomorphological characteristics of an area and its structural soil features.

The attached map does not show the soil regionalization of China below the soil province level. A more minute soil subdivision i to be reflected on special maps provided for the administrative provinces, sub-provinces and districts.

At the end of this review the full text of the legend pertaining to the diagram of Chin soil regionalization is given. An analysis of this diagram and of the data and definitions furnished by the authors leads to the followi conclusions.

The system of China's soil regionalizatio reflects, on the major-unit level, not only t long established distinctions between the eas and western parts of the country, but also, the same or even a larger degree, the latitu al-belt differences of soils between south an north. This latter factor is very important for agriculture because of its relation to the number of harvests per year. Owing to its broad geographic approach, the system of China's soil regionalization can be connected with those of the neighboring countries. This provides a look from the "viewpoint of the continent" at the whole problem of soil regionalization and should be definitely regarded as a major contribution to China's soil geography.

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[1] The author used a Russian translation of the article by Cheng, Sen-chien.

On the basis of this approach China is divided into 13 soil-bioclimatic regions which are at the same time included in a system of latitudinal belts, determined by temperature conditions, and into another system of meridional sectors (or facies), determined by moisture and continentality. (Only the area of Ching-hai-Tibet with its three soil-bioclimatic regions is left out of these systems). Each region is characterized by a system of horizontal soil zones, by the direction of its zonality, and by structural types of its vertical soil zonality.

The authors determine the horizontal zones and sub-zones on the basis of the latest soil-cartographic data, including a new soil map of China with a 1:4,000,000 scale. They use the following breakdown: brown-forest soils (brown earths) are divided into typical and podzolized soils; cinnamon-brown soils — into typical and leached soils; a separate group of soils called "heilutu" and closely related to gray-cinnamon brown soils is created; semidesert brown soils are divided into light-brown and dark-brown soils; red earths and yellow earths are subdivided into subtropical and tropical ones, the latter to be known as laterite soils. This more detailed classification offers an opportunity to better understand the specific characteristics of each soil-bioclimatic region and to appreciate their agricultural significance.

The authors have also made a substantial contribution to the study and systematization of the vertical structural soils of China's mountain areas. By employing a minute classification of mountain soils and a detailed analysis of soil-cartographic data, they have been able to makr out specific characteristics of the vertical zonality of mountain soils not only for all soil-bioclimatic regions, but also for many soil zones.

Their original approach in determining soil provinces takes into account bioclimatic, as well as orographic peculiarities. In addition to mountain and plain provinces, their regionalization map features semi-mountain provinces which reflect special characteristics of East China where low residual mountains are often alternated with plain areas and have large hilly or flat depressions.

For a better understanding of the scope and significance of this work on soil regionalization of China, its comparison in principle with the latest Soviet efforts in the same field may be useful. In particular, we have in mind the map of soil-geographic regionalization of the USSR which was published in Pochvovedeniye No. 10, 1958.

These two works have many similarities because they employ the same general approach and because the Soviet Union and China have a common border. However, there are certain substantial differences between them. The main ones are as follows:

1) Separation of moderate-warm soil-bioclimatic belt, which according to a number of Chinese soil scientists, does not possess characteristic features of subtropics;

2) Use of somewhat different thermic boundaries for determining soil-bioclimatic territories;[2]

3) Division of each such territory into four (rather than three as is usually the case in Soviet works) soil-bioclimatic regions (humid, subhumid, subarid, arid);

4) Designation of the Ching-hai-Tibet territory not as a region (as it is done in the USSR with regard to Pamir), but as a belt, thus actually excluding it from the latitudinal territory-division of the Earth;

5) Further subdivision of certain soil zones and subzones; soil zones of heilutu-typical and light, zone of brown desert soils, subzone of light-brown semi-desert soils distinguished from subzone of dark-brown (our opinion — it is a peculiar brown) soils which are not regionalized in USSR.

6) Use of a special approach (see above) in separating soil provinces;

7) Subordination of all mountain soil provinces, including high mountains, to soil zones.

The previously mentioned differences are due to various factors which should be analyzed for scientific, as well as for practical reasons. Some of these differences could definitely be attributed to the unique natural and soil conditions of China and should, therefore, be explained in terms of the over-all soil regionalization of Euroasia. Such would probably be the case with the creation of certain special soil zones and sub-zones in China which are not found in the western part of the continent, with the different thermic characteristics of soil-bioclimatic territorial boundaries, with the special evaluation of the nature of the moderate-warm territory.

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[2] While defining the thermic conditions of soil-bioclimatic territories, the author cites, among other data, the following totals of positive temperatures above 10°C: moderate-cold belt, 1500-1700°; moderate 1700-(3000)-3500°; moderate-warm, (3000) 3500-4500°; sub-tropical, 4500-7500°; and tropical belt, 7500-8000°.

At present it would be difficult to explain other differences and we are inclined to think that there is not enough justification for following the exclusion of Tibet from the over-all belt system, the fractional division of soil-bioclimatic territories into regions, and the subordination of the vertical soil structures in all cases not only to soil-bioclimatic regions, but also to horizontal soil zones.

One of the objectives of this review is to prompt Soviet and Chinese soil scientists to study these differences, analyze them thoroughly and to work out a uniform approach to the complex problem of soil regionalization. The correct solution of this problem will be of great importance for agricultures of both countries and will provide a scientific basis for an exchange of agricultural crops, experience and knowledge.

SOIL REGIONALIZATION OF CHINA

(Legend to the diagram)

I. Cold Belt

I A Region of brown-podzolic soils of the southern taiga.

I A 1 Sub-zone of brown-podzolic soils; — mountain provinces; 1) mountain-brown-podzolic and mountain-sod-podzolic soils of northern B. Hao-Kan.

II. Temperate Belt

II A Region of brown earth podzolized coniferous-deciduous forests.

II A 1 Zone of podzolic brown earth; — plain provinces; 1) meadow-gleyed soils (peichiang-tu) and podzolic brown earths of the San-chien plain (Three-River region); mountain provinces: 2) mountain brown earths of podzolized mountains of east Manchuria.

II B Region of chernozems of forest-steppe and steppe.

II B 1 Sub-zone of leached forest-steppe chernozem; — plain provinces: 1) leached chernozem of the foothills of the eastern Manchuria plain.

II B 2 Sub-zone of steppe chernozems; — plain provinces: typical and meadow chernozems of the central Manchuria plain; — semi-mountain provinces: 2) leached and typical chernozems of the hilly foothills of Sanho (Th Rivers); — mountain provinces: 3) mountain-forest gray and mountain-sod-podzolic soils c central B. Hao-kan.

II C Region of chestnut soils of dry steppe

II C 1 Sub-zone of dark-chestnut zones: — plain provinces: 1) dark-chestnut soils of the eastern foothills' plain of southern B. Hao-ka 2) dark-chestnut soils of high flatland of east Hulunpiehr-Hsilimiehngor; — semi-mountain provinces: 3) dark-chestnut and chestnut soi of the low-mountain Chingintolun plateau; 4) chestnut, mountain-chestnut and mountain-br cinnamon-soils of the inter-mountain hollows Enpiehi; — mountain provinces: 5) mountain chernozems and mountain-forest gray soils o southern B. Hao-kan.

II C 2 Sub-zone of light-chestnut soils; — plain provinces: 1) light-chestnut soils of the high flatland of central Hsilimiehngor; 2) ligh chestnut soils of the high hilly flatland of sout ern Ulanchapu; 3) light-chestnut soils of the high flatland of eastern Ortus;-mountain prov inces: 4) mountain-chestnut, mountain-brow cinnamon and mountain-meadow-steppe soils of Tachin-shan.

II D Region of brown semidesert soils, foothill-sierozem and semidesert soils, and gray-brown soils of shrub desert.

PD' sub-province Monhsin (Inner Mongoli Hsingchien)

II D' 1 Sub-zone of dark-brown soils of desert steppe; — plain provinces: 1) dark-brown soils of the high flatland of Wailinmiao Wenturmiao; 2) dark-brown soils of the high flatland of central and western Ordos.

II D' 2 Sub-zone of light-brown soils of steppe-covered desert; — plain provinces: 1) light-brown soils of the high flatland of central and northern Ulanchapu; 2) light-brown soils of the proluvial-alluvial plain of western Ordos and of eastern Alashan; 3) brown soils of the foothill plain of Altai; — mountain provinces: 4) mountain-brown, mountain-chestnut, mountain-brown cinnamo and mountain-meadow-steppe soils of Alansh 5) mountain-brown; mountain-brown-cinnamo and mountain-meadow-steppe soils of Alasha 6) mountain-chestnut, mountain-meadow soil of northwest Altai; 7) mountain-chestnut, mountain-meadow, mountain-forest gray soil of southern Altai.

II D'3 Zone of sierozems of desert steppe

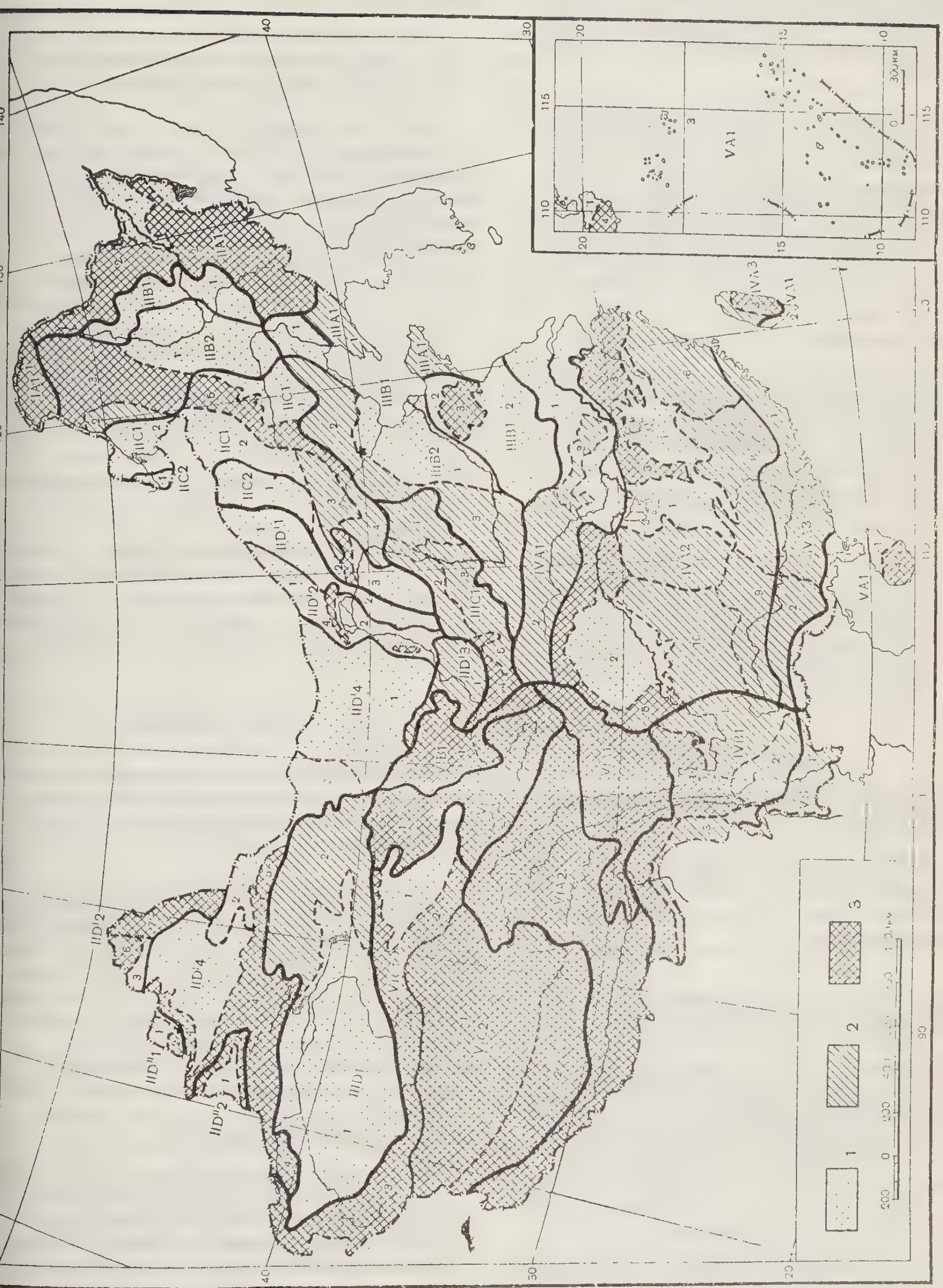

Fig. 1. - Soil regionalization of China.
Composed by: Ma Yun-chih, and Wen Chen-wan.
Provinces: 1 - plain; 2 - semi-mountain; 3 - mountain.

foothills; — semimountain provinces: 1) sierozems, mountain-chestnut and mountain-brown-cinnamon-soils of the intermountain hollows and mountains of Lanchow district in the Hohsi Corridor.

II D' 4 Zone of gray-brown soils of shrub desert; — plain provinces: 1) gray-brown soils of the high flatland Alashan-Eching; 2) gray-brown gypsum-bearing soils of Gobi-Noming; 3) gray-brown soils of the Djunggari hollow; 4) mountain-brown, mountain-chestnut, mountain-brown-cinnamon and mountain-meadow-steppe soils of the eastern Inner Tyan'-Shan'.

PD" Sub-region of Central Asia.

II D" 1 Zone of brown soils of desert steppe; — plain provinces: 1) brown soils of the Eming River plain (r. Dropuldjin); — mountain provinces: 2) mountain-chestnut soils, mountain-chernozem and mountain-meadow soils of the western slope of Chihshan mountain;

II D" 2 Zone of sierozems of desert steppe foothills ; — plain provinces: 1) sierozems of the Ili River valley; — mountain provinces: 2) mountain-chestnut, mountain-chernozem, mountain-brown-cinnamon, mountain-brown earth and mountain-meadow soils of the Inner Tien-Shan.

III. Temperate-warm Belt

III A Region of brown earths of diciduous broadleaf forests.

III A 1 Zone of forest brown earth; — semi-mountain provinces: 1) brown earth and mountain-brown earths of plains and the low Liaotun-Shantun mountains.

III B Region of cinnamon-brown soils of xerophilic forests and forest-steppe.

III B 1 Sub-zone of leached cinnamon-brown soils of xerophillic forests; — plain provinces: 1) leached cinnamon-brown soils in the plain of lower Liaohui River; 2) leached cinnamon-brown soils of the Huang-Huai (Huanhui and Huaihui Rivers); mountain provinces: 3) mountain, cinnamon-brown soils (leached and mountain-burozem soils of Luchung).

III B 2 Sub-zone of cinnamon-brown soils of forest-steppe; 1) cinnamon-brown soils of the Huaihui plain; — semi-mountain provinces: 2) cinnamon-brown, mountain-cinnamon-brown, mountain-brown earth and mountain-meadow soils of the mountains and inter-mountain hollows in northern Hopiehi; 3) cinnamon-brown, mountain-cinnamon-brown, mountain-brown earth and mountain-meadow soils of southern Shanhsi and Kuanchung.

III C Region of heilutu (gray-cinnamon-brown soils) of steppe and dry steppe.

III C 1 Zone of heilutu soils; — semi-mountain provinces: 1) heilutu mountain-cinnamo brown, mountain-brown earth and mountain-meadow soils of the mountains and inter-mountain hollows of central Shanhsi; 2) light heilut and mountain-dark heilutu of the loess plateau and "hills" of northern Shenhsi; 3) heilutu, clay-heilutu and mountain-cinnamon-brown soils of plateau and "hills" of Shenhsi-Kansiu; — mountain provinces: 4) mountain heilutu, mountain-cinnamon-brown and mountain-brow earths of loess plateau and "hills" of central Kansu; 5) mountain-cinnamon-brown and mountain-burozem soils of Lupani-shan.

III D Region of brown desert soils of shrub desert.

III D 1 Zone of brown desert soils; — plain provinces: 1) brown desert soils of the Tarim hollow; — semi-mountain provinces: 2) brow desert and mountain -desert soils of mountain inter-mountain hollows and "gobi" of eastern Hsinchien.

IV. Sub-tropical Belt

IV A Region of yellow-brown earth, yellow brown earth, yellow-cinnamon-brown, yellow-earth, red earths and lateritic soils of humid sub-tropical forests.

IV A 1 Zone of yellow-brown earths and yellow-cinnamon-brown soils of mixed decidu and evergreen forests; — plain provinces: 1) yellow-brown earths and yellow-cinnamon-brown soils of the hilly Chienhuai plain (lower Yangtze and Hwaiho); semi-mountain province 2) yellow-cinnamon-brown, mountain-yellow-brown earths, mountain-brown earth and mountain-meadow soils of the Chinling and Tapashan mountains and inter-mountain hollo — mountain provinces: 3) mountain-yellow-brown earths of Tapashan.

IV A 2 Zone of red earths and yellow eart of evergreen forests; — plain provinces: 1) red earth, of the hilly Huan-Chienhsi plain; 2) yellow earth of the Szechwan basin; — mou tain provinces: 3) mountain yellow earth, mountain-yellow-brown earths and mountain-meadow soils of the mountains on the souther Yangtsu bank; 4) mountain-yellow earth, mountain-yellow-brown earths and mountain-meadow soils of the Tapashan mountains and western Hupiehi; 5) mountain yellow earth, mountain gray-brown earth and mountain-

neadow soils of western Ssuchuaan; — semi-
nountain provinces: 6) red earth, mountain-
'ed earth and mountain yellow earth of Chao-
hiang-Fuchian; 7) red-earth, mountain
ellow earth and mountain-yellow-brown earth
f mountains and inter-mountain hollows of
vestern Huan and eastern Kweichow; 8) red
arth and mountain yellow earth of mountains,
ills and inter-mountain hollows of Nan-ling;
) red earth and yellow earth, mountain
ellow earth and mountain-meadow soils of the
Cuei-chou — Kuang-hsi mountains and hills;
0) yellow earth, mountain yellow earth and
nountain podzolic soils of the Kuei-chou
lateau.

IV A 3 Zone of lateritic soils of evergreen
nonsoon forests; — semi-mountain provinces:
) lateritic soils and mountain yellow earth
f the mountain-hilly maritime Fu-chian —
Cuan-tun plain; 2) lateritic soils, mountain
ellow earth and mountain-meadow soils of the
nountains and inter-mountain hollows in south-
rn Kuang-hsi; — mountain provinces: 3) moun-
ain yellow earth, mountain gray brown earth,
nountain podzolic and mountain-meadow soils
f central Formosa.

IV B Region of lateritic soils and red earth
f variable-humid sub-tropical forests.

IV B 1 Zone of lateritic soils and red
arth — semi-mountain provinces: 1) later-
tic soils plateau of southern Yun-nan; 2)
ateritic soils and mountain red earth of the
nountains and inter-mountain hollows in south
vest Yun-nan; 3) red earth and mountain
ellow earth of the mountains and inter-moun-
ain hollows of western Yun-nan; — mountain
rovinces: 4) mountain red earth, mountain
rown earth mountain podzolic and mountain-
neadow soils of the southern Hotuan mountain
ange.

V. Tropical Belt

V A Region of laterite soils of humic tropi-
al forests.

VA 1 Zone of laterite soils of humid tropi-
al forests; — plain provinces: 1) laterite soils
f the hilly Tsun-lei plain (Lei-chou peninsula,
Iai-nan island); 2) laterite plain soils in
outhern Formosa; 3) black soils of the South
China Sea islands; — mountain provinces: 4)
nountain yellow-red laterite soils, mountain
ellow laterite soils and mountain yellow
arths of Hai-nan Island.

V B Region of laterite soils variable-humid
ropical forests.

V B 1 Zone of laterite soils of variable-
umid tropical forests; — semi-mountain
provinces: 1) laterite soils, mountain laterite soils and mountain yellow earth of mountains and inter-mountain hollows of southern Yunnan.

VI Table-land of Ching-hai — Tibet

VI A 1 Vertical belt of mountain-forest and mountain-meadow soils; — mountain provinces: 1) mountain-brown-cinnamon, mountain brown earth, mountain-podzolic and mountain-meadow soils of the northern Ho-tuan mountain range.

VI A 2 Vertical belt of mountain-steppe and mountain-meadow soils; — mountain provinces: 1) mountain-steppe and mountain-meadow soils of the Hsu-shu table-land and southern Tibet.

VI B Region of mountain-forest and mountain-meadow-steppe soils.

VI B 1 Vertical belt of mountain-forest, mountain-meadow-steppe and mountain-meadow soils; — mountain provinces: 1) mountain sierozem, mountain-brown-cinnamon, mountain brown earth, mountain-meadow-steppe and mountain-meadow soils of eastern Chi-lenshan and southern Kan-su.

VI B 2 Vertical belt mountain-steppe and mountain-meadow soils; — 1) mountain sierozem, mountain-meadow-steppe and mountain-meadow soils of western Chi-len-shan and Kuo-lo-shan.

VI C Region of Desert Soils of Table-land

VI C 1 Zone of desert soils; — plain provinces: desert soils of the Tsai-tam hollow; — mountain provinces: 2) mountain-desert, mountain-steppe and high-mountain (Alpine) cold-desert soils of Kun-lun and Al-tenge-tag; 3) mountain-desert, mountain-steppe, mountain-brown-cinnamon and high-mountain (Alpine) cold-desert soils of Kara-kun-lun.

VI C 2 Zone of cold-desert soils; — mountain provinces: 1) high-mountain (Alpine) cold-desert soils of the Chiang-tang table-land; 2) province of high-mountain (Alpine) steppe and high-mountain (Alpine) cold-desert soils of the Kai-las mountain range.

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